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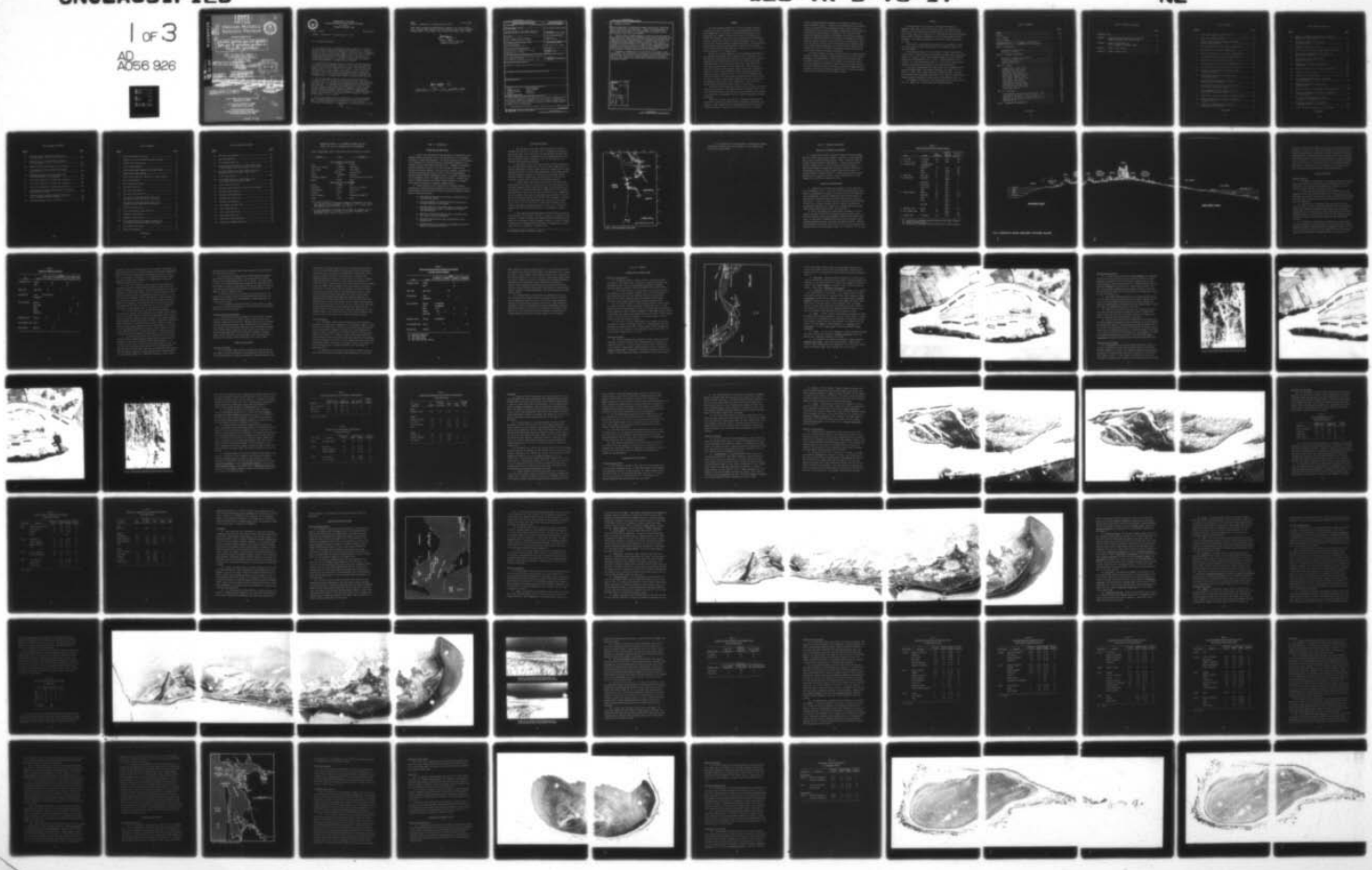

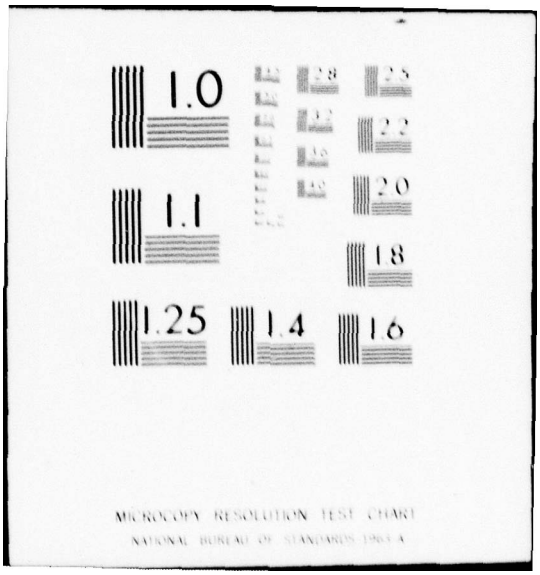
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DREDGED MATERIAL RESEARCH PROGRAM

TECHNICAL REPORT D-78-17

COLONIAL NESTING SEA AND WADING BIRD USE OF ESTUARINE ISLANDS IN THE PACIFIC NORTHWEST.

by

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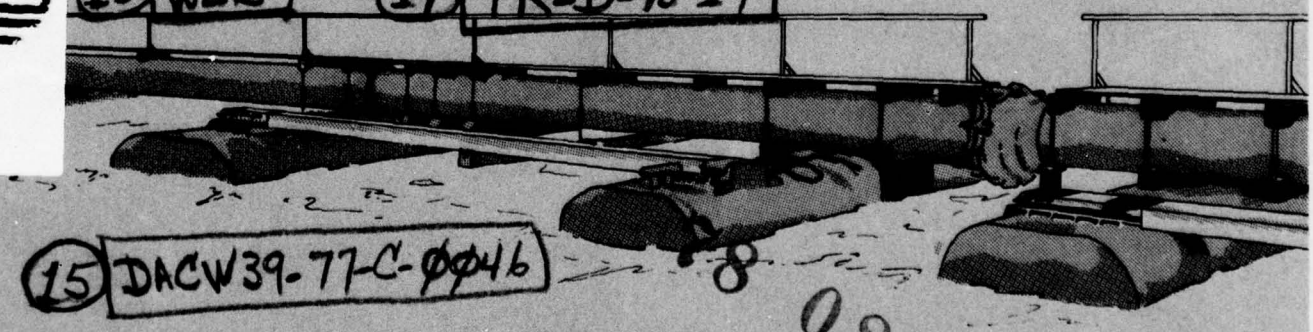

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Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

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Monitored by Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
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IN REPLY REFER TO: WESYV

30 June 1978

SUBJECT: Transmittal of Technical Report D-78-17

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of Work Unit 4F01E regarding the vegetation and wildlife use of dredged material islands in the Pacific Northwest. This work unit was conducted as part of Task 4F (Island Habitat Development) of the Corps of Engineers' Dredged Material Research Program (DMRP). Task 4F was part of the Habitat Development Project of the DMRP and has as its objective the investigation, evaluation, and testing of methodologies for habitat creation and management on dredged material islands.

2. Island habitat development has been studied by the DMRP throughout the United States through the evaluation of vegetation succession and animal use of existing dredged material islands. The most significant wildlife aspect of these islands is their use by colonial nesting sea and wading birds (such as gulls, terns, egrets, herons, ibises, and pelicans). This wildlife resource, although generally inadvertently created, presents a significant opportunity for habitat management and development that is consonant with continued dredged material disposal.

3. In the study reported herein, 23 natural and dredged material islands were examined in seven locations from Anacortes, Washington, to Coos Bay, Oregon, to establish the relationship between plant communities and animal use. The principal use of dredged material islands was by gulls and terns. It was noted that adequate natural habitat for other colonial nesting species existed and, by comparison, use of dredged material islands was minimal. Existing habitat on dredged material islands could be improved by selective deposition of additional material; however, the production of new dredged material islands for colonial nesting species is not necessary.

4. From a local perspective, this study will be of value in managing and developing dredged material island habitats in the Pacific Northwest. A national perspective is presented in a report entitled "Development and Management of Avian Habitat on Dredged Material Islands,"

WESYV 30 June 1978
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(4F03) which synthesizes island habitat research in the Pacific Northwest, the Great Lakes (4F01A), New Jersey (4F01D), North Carolina (4F02), Florida (4F01C), Texas (4F01B), and the Upper Mississippi River (4F01F).

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

410 779 (New
Graham (John) Co., Seattle, WA.

Unclassified

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REPORT DOCUMENTATION PAGE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Twenty-three natural and dredged material islands were examined in seven locations from Anacortes, Washington, to Coos Bay, Oregon, to establish the relationships between plant communities and use by colonial nesting waterbirds for both types of islands, as well as the actual bird use of dredged material islands in the Pacific Northwest.

Nine islands were found to be used for nesting by one or a combination of

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20. ABSTRACT (Continued)

glaucous-winged gulls, western-glaucous-winged (hybrid) gulls, ring-billed gulls, Caspian terns, and common terns. Colonies of great blue herons were found on two islands 61 and 97 km from the mouth of the Columbia River. Habitat maps were prepared for each island studied and detailed floristic descriptions of each bird colony evaluated.

Colony location, breeding phenology, and nesting success were analyzed with respect to existing flora, environmental stress, island physiography, and human disturbance. Results showed that although dredged material deposition influenced an island's physical dimensions, topography, and substrate, plant communities were physiognomically similar to natural islands. Seabird colonization occurred irrespective of dredging history. Nesting populations appeared to be greater in areas of low human disturbance. Colonization and productivity were primarily related to protection from environmental stress. Indications were that gull and tern nesting on dredged material islands is minimal compared to seabird productivity on natural islands.

Management of dredged material islands should not be directed toward increased gull and tern production, but existing colonies should be maintained and monitored. Common terns are a unique addition to Pacific Northwest avifauna and should be protected. Dredged material deposition could improve habitat on some islands by providing increased stability and protection from environmental stress.

SUMMARY

From June through September 1977, Pacific Northwest estuarine islands were studied to establish the relationships between habitats plant communities, utilization by colonial nesting waterbirds, and dredged material disposal. Twenty-three natural and dredged material islands were examined in seven locations from Anacortes, Washington, to Coos Bay, Oregon. Nine islands were used for nesting by one or a combination of the following species: glaucous-winged gulls, western/glaucous-winged (hybrid) gulls, ring-billed gulls, Caspian terns, and common terns. Colonies of great blue herons were found on two islands 61 and 97 km from the mouth of the Columbia River.

Colonies of more than 1000 pairs of western/glaucous-winged gulls were observed on East Sand Island (Columbia River), Gunpowder Island (Willapa Bay), and Sand and Goose islands (Grays Harbor). Pure glaucous-winged gulls were found further north on Jetty Island and 500 pairs colonized a chain of four islands in Padilla Bay. Over 2000 Caspian terns nested on two islands in Grays Harbor and a small colony was located in Willapa Bay. Ecologically unique observations included the discovery of seven common tern nests on Jetty Island and nine ring-billed gull nests on Whitcomb Island. This study also documented the range of hybridization between glaucous-winged and western gulls along the coast. A colony of approximately 100 pairs of great blue herons was investigated on Ryan Island in the Columbia River and a previously reported 300-nest heronry on Fisher Island was described.

Generalized habitat maps were prepared for each island and detailed floristic descriptions of each bird colony were evaluated. Colony location, breeding phenology, and nesting success were analyzed with respect to existing flora, environmental stress, island physiography, and human disturbance.

Results of the study indicated that, although dredged material deposition influenced an island's physical dimensions, topography, and substrate, plant communities were physiognomically similar to natural islands and seabird colonization occurred irrespective of dredging

history. Nesting populations appeared to be greater in areas of low human disturbance; however, colonization and productivity were primarily related to protection from environmental stress. Subtle processes of deposition and accretion and more dramatic changes due to high tides and storms greatly affected habitat availability. Gulls nested in both natural and manipulated habitats. Although not selective with regard to vegetative community structure, they required the presence of at least early successional species to nest successfully. Terns were more selective with respect to colony location and nested only on sparsely vegetated, natural appearing habitats. Both heron colonies occurred in the tallest trees close to the center of undisturbed islands near shallow waters which provided an adequate food supply.

This study indicates that gull and tern nesting on dredged material islands is minimal compared to seabird productivity on natural islands. Management of dredged material islands should not be directed toward increased production of gull and tern species, but existing colonies should be maintained and monitored. Common terns are a unique addition to Pacific Northwest avifauna and should be protected. Dredged material deposition could improve habitat on some islands by providing increased stability and protection from environmental stress.

PREFACE

Work described in this report was performed under Contract DACW39-77-C-0046 (Neg.) entitled "Study of the Use of Dredged Material Islands by Colonial Nesting Sea and Wading Birds in the Pacific Northwest," dated 4 May 1977, between the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, and John Graham Company, Seattle, Washington. The study was sponsored by the Office, Chief of Engineers, U.S. Army.

This report is a description and analysis of the habitats, vegetation, and waterbird nesting characteristics of estuarine islands in the Pacific Northwest.

Principal participants in the activities of research and analysis were Mr. Carl F. Peters, Director, Environmental Studies Group, John Graham Company, Dr. Klaus O. Richter (John Graham Company), Dr. David A. Manuwal (University of Washington), and Dr. Steven G. Herman (Evergreen State College). Mr. William Harrington-Tweit, Mr. Ulrich Wilson, and Ms. Naomi Manuwal provided additional assistance with field observations.

The contract was managed by Ms. Mary Landin of the Dredged Material Research Program (DMRP), Environmental Laboratory (EL), WES. Dr. R. F. Soots, Jr., WES, and Ms. Landin provided a technical review. The study was conducted under the general supervision of Dr. Hanley K. Smith, Project Manager, Habitat Development Project, and Dr. John Harrison, Chief, EL.

The Commander and Director of WES during the conduct of this study was COL J. L. Cannon, CE. Mr. Fred Brown was Technical Director.

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LIST OF FIGURES (concluded)

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) AND
METRIC (SI) TO U.S. CUSTOMARY UNITS OF MEASUREMENT

Units of measurement used in this report can be converted as follows:

Multiply	By	To Obtain
	U.S. Customary to Metric (SI)	
feet	0.3048	metres
miles (U.S. Statute)	1.609344	kilometres
cubic yards	0.7645549	cubic metres
acres	4046.856	square metres
acres	0.4046856	hectares
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
miles	0.8684	knots
	Metric (SI) to U.S. Customary	
metres	3.2808	feet
kilometres	0.6214	miles (U.S. Statute)
square metres	10.76	square feet
hectares	2.471	acres
Celsius degrees	9/5	Faharenheit degrees**
knots	1.152	miles

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9) (F - 32). To obtain Kelvin (K) readings, use K = (5/9) (F - 32) + 273.15.

** To obtain Fahrenheit (F) readings from Celsius (C) readings, use the following equation: F = 9/5 (C) + 32. To obtain Fahrenheit from Kelvin (K), use F = 9/5 (K - 273.15) + 32.

PART I: INTRODUCTION

Background and Objectives

1. Little prior research has been conducted to establish the use of dredged material islands by colonial nesting seabirds in the navigable waterways of Oregon and Washington. One notable exception is an evaluation of the physical and biological impacts of maintenance dredging on the avifauna in Grays Harbor (Smith and Mudd 1976). Dredging and subsequent material deposition, however, occur over all major coastal Pacific Northwest and inland channels. This study was, therefore, conducted for the Waterways Experiment Station as part of their Dredged Material Research Program, Habitat Development Project, to provide information on the environmental effects of dredged material disposal. Islands influenced by dredged material and natural islands unaffected by dredging were studied and compared to evaluate dredging effects.

2. Broad objectives of the study were to establish baseline information on colonial nesting waterbird use by describing the relationships between island habitats and waterbird nesting and fledging success. Specific objectives included:

a. Describing the physical and biological characteristics of each esturaine island;

b. Locating, mapping, and semiquantitatively describing of all major habitats on the islands;

c. Assessing bird use of each major habitat, including location and mapping of primary, secondary, and tertiary bird nesting areas;

d. Physically characterizating nest sites, including elevation, slope, and other parameters;

e. Describing quantitatively plant associations at bird colonies; and

f. Assessing clutch size, hatching and fledging success, and general population productivity.

Location and Climate

3. The locations of the study areas are depicted in Figure 1. Although Coos Bay (43° 25' latitude, 124° 15' longitude) was initially part of the study, sites intensively surveyed extended from Baker Bay (46° 16' latitude, 124° 0' longitude) on the Oregon/Washington coastal border northeast 250 km to Padilla Bay (48° 28' latitude, 122° 31' longitude) and Coos Bay was omitted.

4. The climate in the study region is moist and mild because of the prevailing westerly winds from the Pacific Ocean. Summer winds are usually southwesterly, whereas winter storms are characterized by strong southeasterly winds up to 40 knots* Combinations of high winds and high tides may completely inundate low-lying coastal and inland islands. Sometimes midwinter storms bring cold winds from the north and east, resulting in several days of below-freezing weather and snow.

5. Average annual temperatures are about 10°C with winter and summer means of 5°C and 16°C, respectively. A frost-free season extends from April through October. Both coastal (Baker Bay, Willapa Bay, and Grays Harbor) and inland (Columbia River, Duwamish River, Port Gardner, and Padilla Bay) study sites are characterized by cool, dry summers and mild, wet winters. Mean January temperatures range between 3°C and 8°C, and July temperatures between 15°C and 19°C (U.S. Department of Commerce 1977). April through July temperatures were coolest at Grays Harbor (9.6°C, 10.1°C, 12.7°C, and 14.6°C, respectively) and other coastal islands, and warmest near Kellog (12.0°C, 12.5°C, 17.2°C, and 18.4°C, respectively) and other inland islands (U.S. Department of Commerce 1977).

6. Mean annual precipitation ranges from 200 to 300 cm along the coast and 60 to 120 cm inland, of which 75 percent falls between October and March. December and January have maximum rainfall averaging approximately 40 cm per month. Spring and summer rainfall is variable although, in general, April through July precipitation is highest within coastal study sites (U.S. Department of Commerce 1977).

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* A conversion table is provided on page xi.

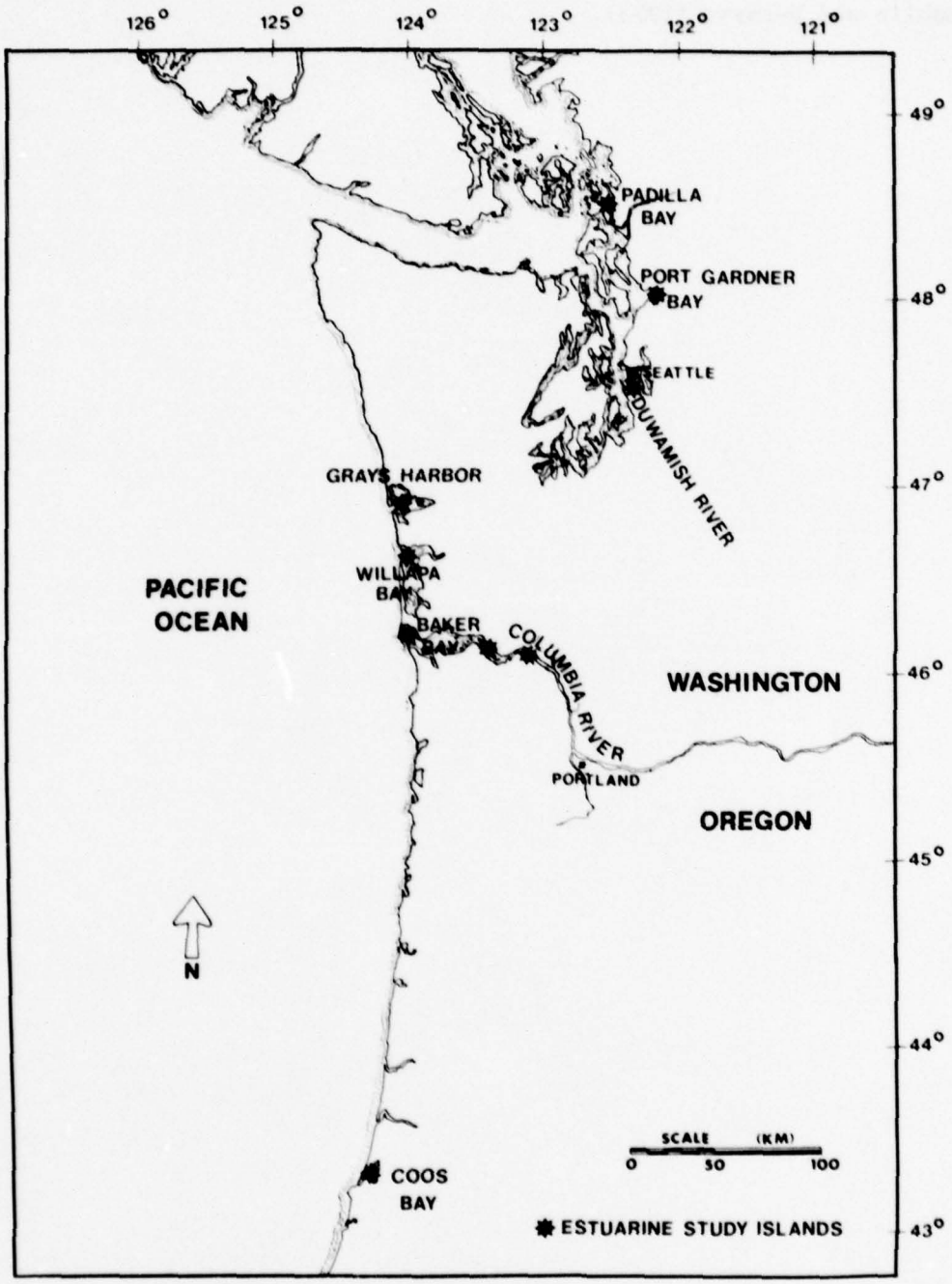


FIGURE 1. PACIFIC NORTHWEST STUDY AREAS

7. More information concerning climate and additional general information concerning soils and vegetation can be obtained from Franklin and Dyrness (1973).

PART II: MATERIALS AND METHODS

Selection of Islands to be Studied

8. Islands were initially selected if they had received dredged material deposits and were near enough to the Pacific coast (within 80 km) to attract colonial nesting seabirds. Table 1 shows the areas and islands reviewed during the investigation. Islands deleted from the original proposal were not used for nesting by colonial seabirds. Other study islands were added when literature reviews, contacts with knowledgeable persons, and field studies indicated the presence of nesting seabirds or dredged material. Islands without birds or known dredged material deposits received a cursory investigation to allow comparison of utilized and nonutilized areas.

Selection of Habitat Types

9. A general air and ground reconnaissance of each island was made in midsummer of 1977. From these surveys, tentative habitat types based upon physiography, substrate, and plant structure and composition were distinguished. Relatively homogeneous regions (with respect to these physical and botanic characteristics) were selected for island description. At least 15 habitat types were intensively sampled because of their use by colonial nesting seabirds. Habitat description and successional terminology for islands are a composite derived from Byrd 1950; Hanneson 1962; Jefferson 1975; and Eilers 1975.

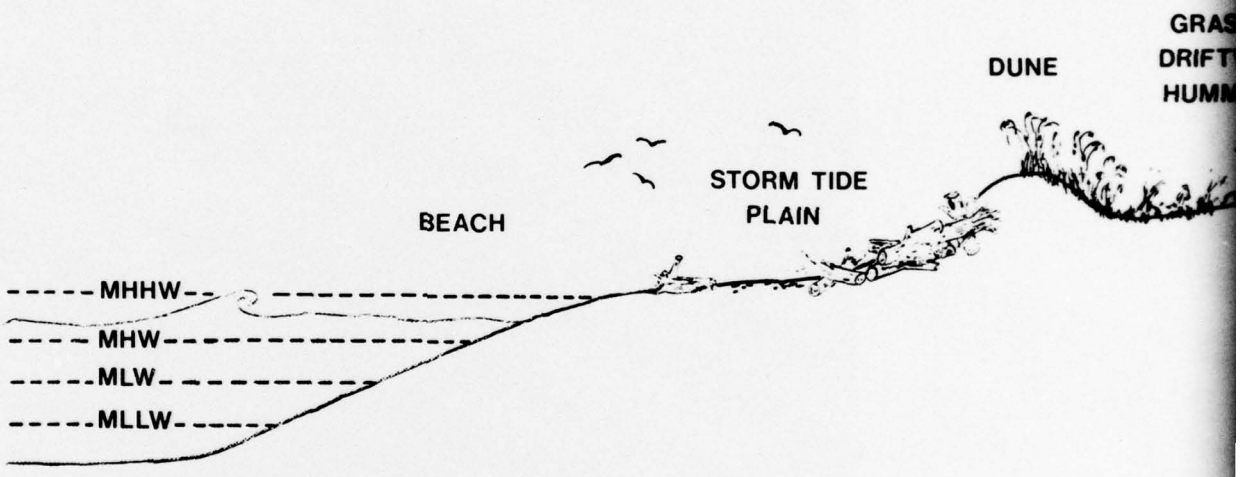
10. Aerial photographs and ground surveys throughout the field season were used to establish the boundaries between habitat types. In addition, National Oceanic and Atmospheric Administration (NOAA) charts and U. S. Army Corps of Engineers publications were consulted to help establish boundaries between intertidal and upland locations. Habitats were delineated according to the extent to which they are influenced by various factors of the environment (Figure 2). In general, the two main

Table 1

Study Islands and Their Characteristics

	Area	Island	Result of Review*	Colonial Nesting Species	Influenced by Dredged Material
1.	Coos Bay	4 Islands	OD	None	Yes
2.	Tillamook Bay	1 Island	OD	None	No
3.	Columbia River	4 Islands within 16 km of Astoria	OD	None	Yes
		Ryan	A	Heron	No
		Fisher	A	Heron	Yes
4.	Baker Bay	East Sand	A	Gull	?
5.	Willapa Bay	Gunpowder	A	Gull, Tern	?
		Whaleback	A	None	?
		North Snag	A	None	?
		South Snag	A	None	?
		Pine	A	Gull	?
6.	Gray's Harbor	Rennie	OR	None	Yes
		Half Moon	OR	None	Yes
		Goose	A	Gull	?
		Sand	A	Gull, Tern	?
		Whitcomb	A	Gull, Tern	?
7.	Duwamish River	Kellog	A	None	Yes
8.	Port Gardner Bay	Jetty	OR	Gull, Tern	Yes
9.	Padilla Bay	5 Islands	OR	Gull	Yes

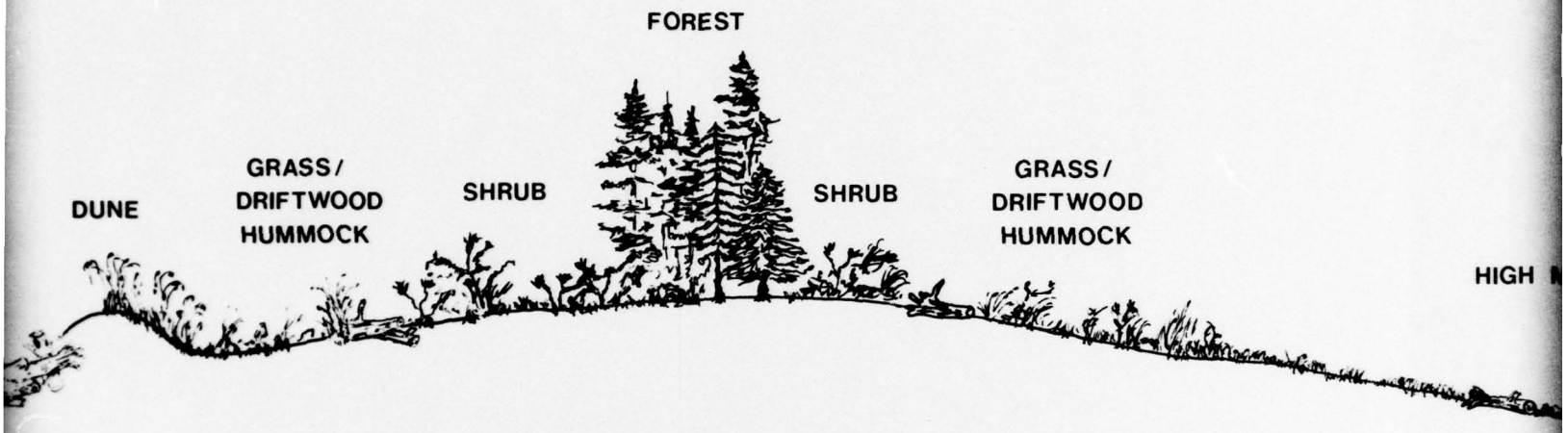
* OD: Originally in proposed study and deleted from further analysis.
A: Added to proposed study.
OR: Originally in proposed study and retained for further analysis.



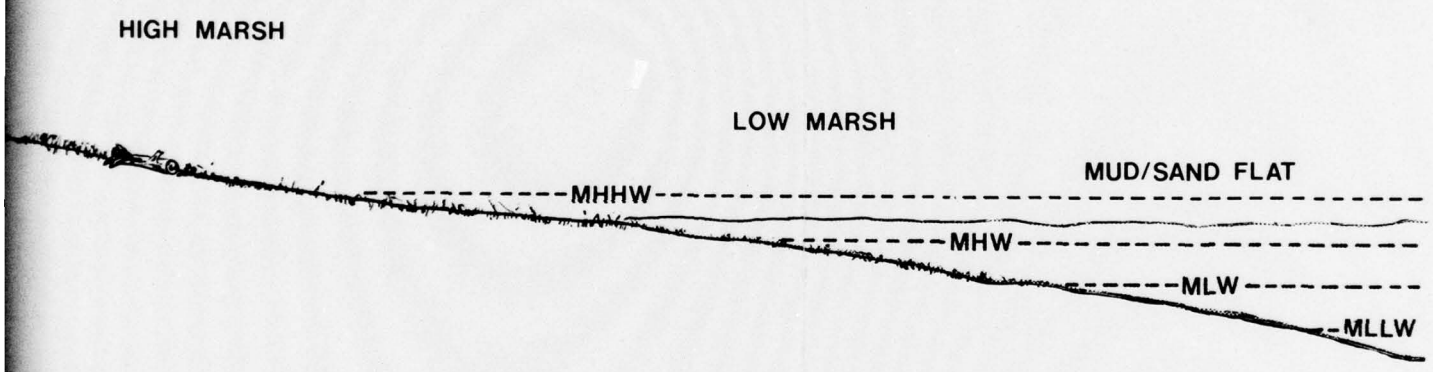
EXPOSED COAST

FIG. 2 HABITATS OF PACIFIC NORTHWEST ESTUARINE ISLANDS

1


FOREST
DUNE
GRASS/
DRIFTWOOD
HUMMOCK
SHRUB
SHRUB
GRASS/
DRIFTWOOD
HUMMOCK
HIGH

2



SHELTERED COAST

categories, intertidal and upland, are based on the overriding influence that water, in the form of tides and the energy of wave action, plays in island characterization. In addition, two minor categories, exposed and sheltered, refer to additional physical factors. Specifically, exposed sites exhibit greater fluctuations in wave exposure, a smaller influence of tidal coverage, more severe battering by drift logs and other debris, and greater stress due to desiccation and heat than sheltered habitats. Additionally, exposed habitats are colonized by species that are not able to tolerate salinity variations of sheltered localities.

Study of Vegetation

Sampling technique

11. To minimize adverse effects on feeding, nesting, and fledging birds, plant distribution and density were recorded at distinct dates, depending on location and breeding phenology of colonies. For each island, systematic sampling was conducted (Table 2).

12. Voucher specimen preparation, species identification, and community descriptions occurred throughout the field season. True color photographs taken during flights greatly aided in community descriptions, especially when differentiations were made between several of the marsh and grass communities.

13. Transects were established within each habitat type of a breeding colony or within an important vegetative type of a non-colony island. These transects extended through the center of each habitat perpendicular to the topographic contours. These methods best described vegetation within the colony, while at the same time vegetation change was revealed along an environmental gradient or marked topographic features.

14. Vegetation quantification was adjusted to consider characteristics of growth form and distribution, and resulted in two distinct sampling techniques. Grasses and herbs were sampled in either 1 x 1 m or in 0.5 x 1-m plots every other m along opposite sides of the transect. Shrub and tree vegetation was measured within 4 x 4-m plots at 4-m

Table 2

Vegetation Sampling Schedule

Area	Island	Date: June	July	August	Sept.	October
Columbia River	Fisher		●		●	
	Ryan		●		●	
Baker Bay	East Sand	●		●		
Willapa Bay	Pine	No vegetation				
	Gunpowder					●
Gray's Harbor	Rennie					●
	Half Moon					●
	Sand				●	
	Goose				●	
	Whitcomb					●
Duwamish River	Kellog	●		●		
Port Gardner Bay	Jetty		●			
Padilla Bay	Padilla		●			

intervals, again on alternating sides of the transect. Tree density was additionally measured by the point-centered quarter method (Greig-Smith 1964), in which the distance from each sampling point to the nearest tree in each quadrat is measured. In all sampling techniques, transect location and length were determined by a combination of vegetation homogeneity and bird colony size.

15. Grass, herb, and small shrub vegetation data recorded and subsequently analyzed included species observed, percent cover, frequency of occurrence, and height. Quantification parameters followed the terminology of Greig-Smith (1964), in which cover was defined as "the portion of ground occupied by perpendicular projection onto it of the aerial parts of individuals under consideration," percent frequency as the percentage of samples in which each species has been found, and density as the number of plants per unit area. Data for each transect were summed and divided by the respective 1-m^2 or 0.5-m^2 quadrats to extrapolate average percent cover for each species per quadrat.

16. Relative importance values based on the combination of percent cover and frequency were calculated for each plant species within a specific life form. Importance values are traditionally defined as the sum of the relative density, relative frequency, and relative dominance (Mueller-Dombois and Ellenberg 1974). However, in grass-herb habitats in which seabirds nest, relative dominance (usually defined in terms of basal area) and density (defined in terms of individuals of a species) are less meaningful parameters than percent cover. Therefore, in this report importance values of species were based on percent cover and frequency and reach a maximum of 200 in habitats of only one species.

17. In heronries, vegetation data were based on 0.5-m^2, 16-m^2, and point-centered quarter sampling schemes which measured different parameters to determine additional species characteristics. It is possible in some cases to reduce the stem count (density) values from the 16-m^2 plots, add them to the percent cover and frequency data obtained from the 0.5-m^2 plots, and obtain an importance value based on three parameters. However, the same species were not always observed in each sampling scheme and, to maintain consistency in this report,

importance values in heronies were based on percent cover and frequency data from the 0.5-m^2 plots.

18. Shrub and tree quantification included additional measurements within the quadrat of number of stems and diameter at breast height of tree species greater than 8 cm in diameter. The total number of stems for each shrub species were counted and the sum divided by the total number of stems per 16-m^2 quadrat. The average number of stems for each species per hectare was extrapolated by multiplying the average number of stems per quadrat by 625.

19. Mean tree area was calculated by squaring the mean of all measured tree distances from the point-centered sampling scheme. This number was then divided into 10,000 (number of square meters per ha) to give density values.

20. To determine successional patterns, the presence of younger plants, age and growth characteristics of older plants, and proportional distribution of each were noted.

Identification and preservation

21. Plants were collected throughout the field season, although special efforts were made to obtain flowers, seeds, and other taxonomically characteristic structures. Specimens were stored in vasculums and other appropriate apparatus until identification and preparation were possible. Most plants were identified prior to mounting. Representative mounted voucher specimens of each species were submitted to the Waterways Experiment Station for verification. Taxonomy, including genus, species, authority, and common name, follow the nomenclature of Hitchcock and Cronquist (1973) and Hitchcock et al. (1955, 1969).

Study of Bird Colonies

Location of colonies

22. An initial flight over the proposed study area was made in late April to verify the location of the islands and their use by colonial nesting seabirds. At least one additional flight was made over each

area chosen for further analysis to locate islands and nesting areas. Aircraft altitude during general reconnaissance varied, depending on island and colony size, but was typically 300 m. Overflights of 80 to 150 m were made to delineate colony boundaries or habitat types. Chartered Cessna 172 aircraft were used, since the wing-over fuselage design allowed better visibility. These flights were generally not useful for actual censusing since the birds occurred in such low numbers (less than 2000). Aerial observation was most helpful in verifying utilization of islands which had been suggested for study following a literature search and contacts with knowledgeable persons. Black and white and color oblique photographs were made on each flight. Vertical black and white photographs were obtained from the U. S. Army Engineers, Portland and Seattle Districts, for study areas with recent coverage. Vertical photographs for Grays Harbor and Willapa Bay islands were taken especially for this project. Table 3 shows the dates that population estimates and nest censuses were obtained on each island. Islands in the Columbia River, Baker Bay, and Willapa Bay were censused later in the season than others since they were added to the study only when it was learned they supported breeding colonies.

Census techniques

23. The number of gulls and terns nesting on each island was determined in several ways, depending on the approximate number of birds and type of nesting habitat. Estimates were made by counting individual nests, representative sampling of nesting areas, and estimating the number of adults in small (10 to 50) flocks adjacent to nesting areas. Variations in habitats or colonies on some islands required different census techniques. Where different methods were used, they are described within the discussion of results for each island. Nests were counted and noted whether empty, with eggs, or with chicks. Based on the amount of cover obscuring nests, an estimate was made of the percentage of undetected nests.

24. During the first visit to each island, at least 10 nests in each colony were marked to determine nesting phenology. In areas with

Table 3

Colonial Nesting Species Population Estimates and Nest Census Schedule

Area	Island	Date: May*	June*	July*	August*
Columbia River	Fisher			●	
	Ryan			●	
Baker Bay	East Sand		GG		
Willapa Bay	Pine		G		
	Gunpowder			B	
Gray's Harbor	Rennie	NO NESTING			
	Moon	NO NESTING			
	Sand	● ● T		●	G
	Goose	● G	G		
	Whitcomb	B		B	B
Duwamish River	Kellog	NO NESTING			
Port Gardner Bay	Jetty		B		B
Padilla Bay	Padilla		G	G	

* ●: Population Estimate
G: Gull Nest Census
T: Tern Nest Census
B: Gull and Tern Nest Census

dense vegetation, nests were marked with a 1 to 1.5-m stick painted Day-Glo orange on one end and placed upright in the ground at least 1 m from the nest. In other colonies, white plastic tape was tied to vegetation or driftwood within 0.5 to 1.5 m of the nest. Individually marked shells were used to identify tern nests. Information was recorded pertaining to existing nest use, vegetation, slope, substrate, and distance to adjacent nests. Additional observations were recorded concerning the location of major seabird loafing areas, other species of nesting birds, signs of predation or human disturbance, and interrelationships between nesting species.

25. Determination of the heron colony populations on the two study islands in the Columbia River was difficult since the colonies were not discovered until early July. By this time, dense vegetation obscured the nests and made accurate bird and nest counts impossible. The number of nests was determined from aerial photographs and ground observation during site visits, and by comparison with earlier counts made by U.S. Fish and Wildlife Service personnel. A determination of nesting phenology and success of these colonies was not possible.

PART III: RESULTS

Columbia River, Fisher Island

Physical characteristics

26. As shown in Figure 3, Fisher Island is located 97 km above the mouth of the Columbia River, 9 km west of Longview, Washington, and approximately 200 m south of the Washington mainland. The greatest length and width of the 84-ha island are 1900 and 700 m, respectively.

27. The island's interior is relatively low (less than 10 m) and flat; however, at the periphery elevation drops 2 m to the Columbia. A long slough penetrates from the northwest and northeast towards the center of the island. Scattered logs, dead branches, and driftwood within the island boundary indicate that periodic flooding occurs.

28. In the early 1900's, a large central portion of Fisher Island was cleared of timber, farmed, and grazed. Records from the U. S. Army Engineer District, Portland, show no history of dredged material influence on the island since 1939. However, beginning in 1948, Hump Island, directly to the south, was created from dredged material and joined to Fisher Island in 1973. A small shallow bay adjacent to the southern margin of Fisher Island has resulted from this activity.

29. The soils of Fisher Island grade from an organic muck along the northern perimeter and slough channels to a predominantly sandy soil throughout the higher upland sites. A heavy annual litter increment has not resulted in the creation of any substantial organic layer since the A horizon only ranged from 0.1 to 2.5 cm.

Habitat description

30. The four habitat types described on Fisher Island were based primarily on periodic Columbia River flooding and the distribution of vegetation (Figure 4). Two types, grass-herb and forest, characterized by the dominant stinging nettle (Urtica dioica) and black cottonwood (Populus trichocarpa), respectively, covered more than 90 percent of the island. A narrow, high marsh habitat surrounded the island and extended

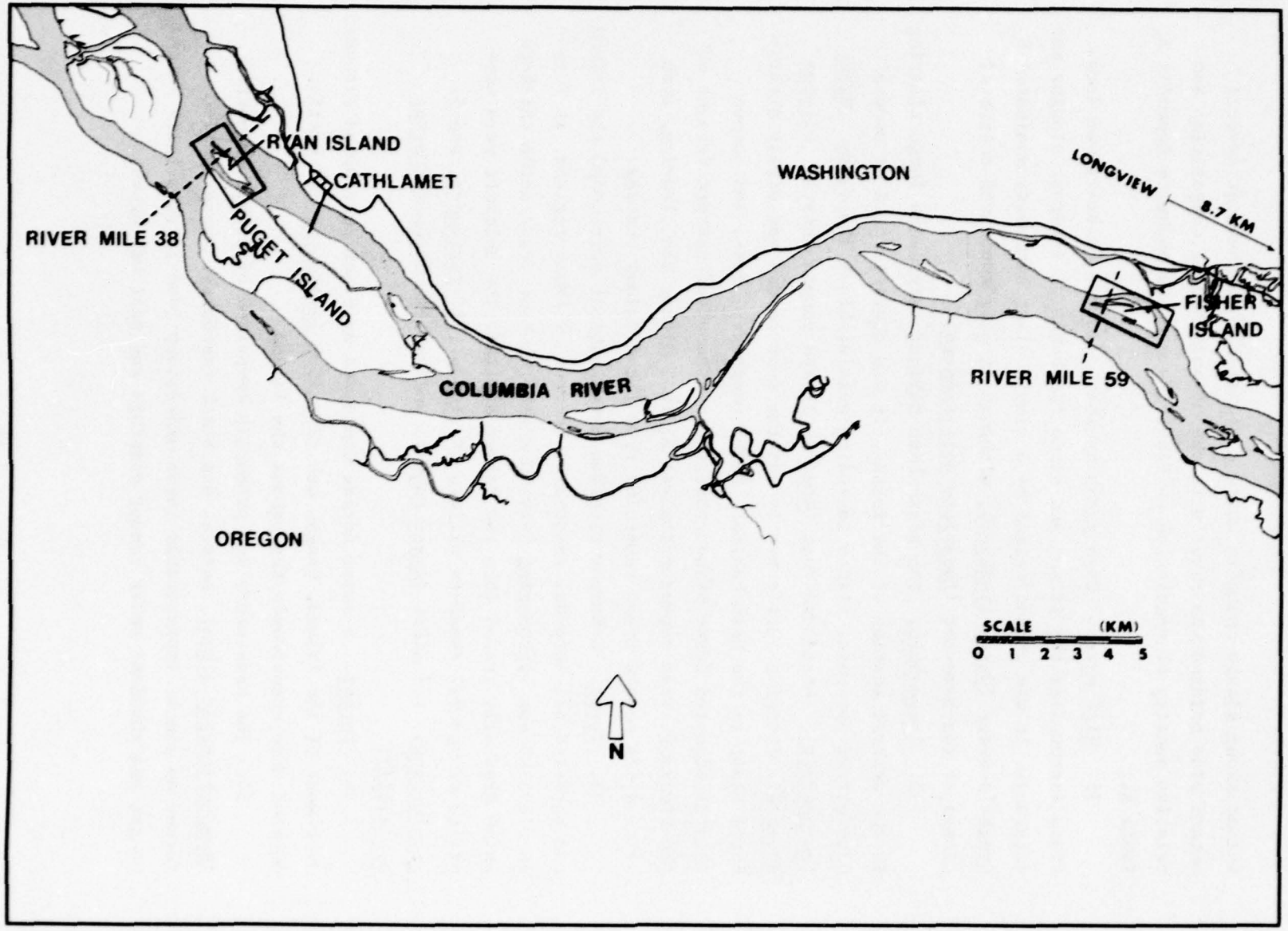


FIG. 3 COLUMBIA RIVER STUDY AREAS

inland along slough channels where a riparian shrub habitat several meters wide bridged the river with the upland forest. Composition and relative density of vegetation on Fisher Island are shown in Appendix A, Table A1.

31. High marsh. High marsh habitat occurred in scattered locations surrounding the island and along the banks of internal sloughs and waterways. It was characterized by a simple plant community dominated by Lyngby's sedge (Carex lyngbyei), although it also contained scattered clumps of touch-me-not (Impatiens noli-tangere).

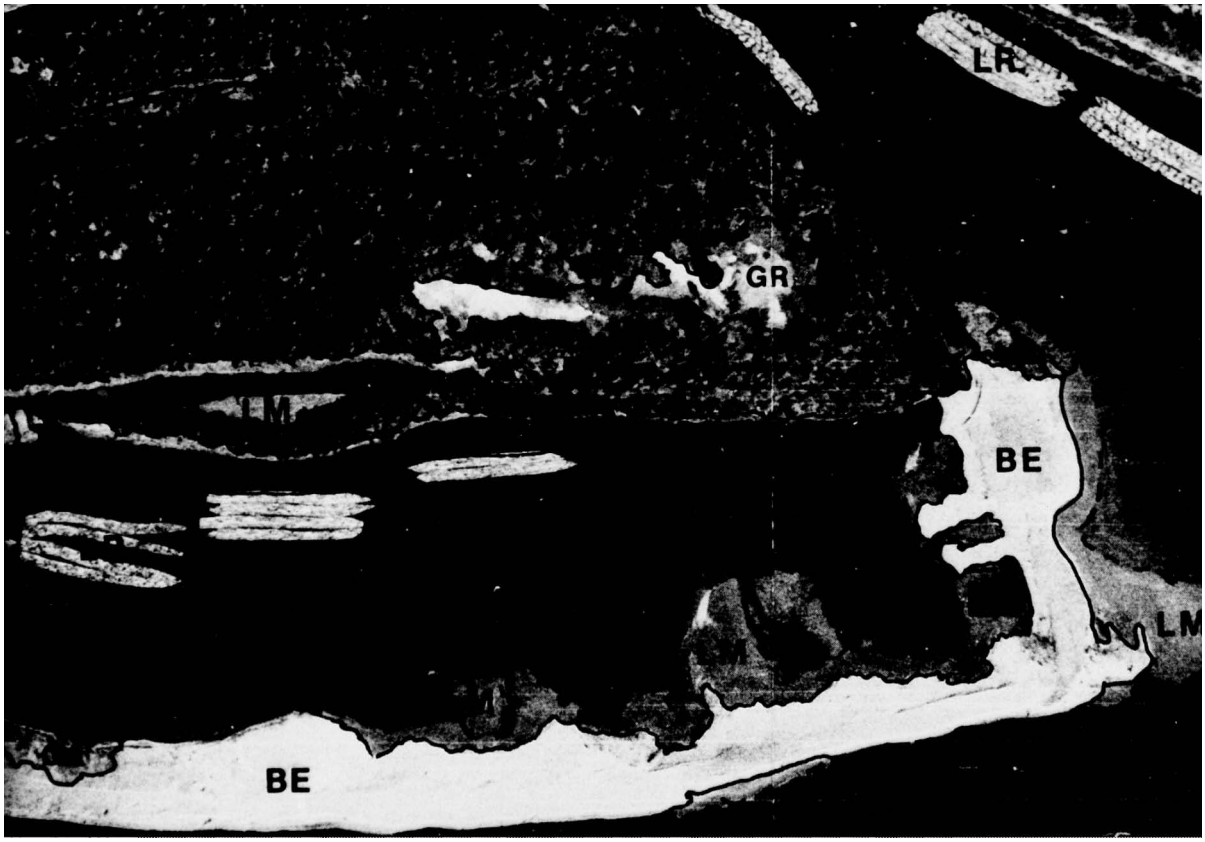
32. Grass-herb. The grass-herb habitat occupied a large clearing in the central section of the island. It was characterized by several naturalized perennial plants including nettle, black raspberry (Rubus leucodermis), introduced rose (Rosa sp.), and common thistle (Cirsium arvense). Stinging nettle was by far the most common and widely distributed plant in the herb habitat. Black raspberry, rose, and common thistle occupied dense stands near the northern and eastern fringes of the clearing. Tree reproduction was minimal within the clearing, even below a few mature trees remaining from the original cutting.

33. Shrub. A narrow riparian shrub habitat surrounded the island and bordered all internal waterways. In most of these regions, it formed an elevated and overhanging 5-to 10-m wide bank of dense shrub thickets which gradually graded into the forest habitat. The thickets were comprised of several immature willows (Salix sp., S. lasiandra, and S. scouleriana), red alder (Alnus rubra), and Pacific dogwood (Cornus nuttallii).

34. Forest. A seral forest dominated by black cottonwood extended over most of the island. Oregon ash (Fraxinus latifolia) and Pacific dogwood were codominants throughout the island.

35. The understory was primarily comprised of common snowberry (Symphoricarpos albus), nettle, and black raspberry. These species formed an almost impenetrable shrub understory 1-to 1-1/2-m tall. Touch-me-not was abundant under canopy openings and near wet areas.


BE
Beach
LM
Low Marsh – Sedge
GA
Grass – Velvetgrass
GR
Grass-Herb – Velvetgrass
SH
Riparian Shrub – Willow
LR
Log Raft
GA
BE
GA


LR
GR
LM
BE
LM
BE

Colonial nesting species

36. A colony of great blue herons (Ardea herodias) has reportedly nested on this island for some time, but was first visited by trained biologists in March and April 1977 (personal communication, 15 June 1977, Susan Saul, Public Use Specialist, U.S. Fish and Wildlife Service, Longview, Washington). The first visit of this study occurred 7 July 1977, near the peak fledging period. As shown in Figure 5, the colony was located in the center of the eastern half of the island and occupied an area of less than 1 ha.

37. The primary nesting area was in the tallest black cottonwood trees (25 to 32 m) on the island, adjacent to a small clearing. Access to the area was extremely difficult due to the dense shrub and herb understory. Dense growths of stinging nettle and common snowberry beneath the colony also hampered observation of the nests.

38. During the first visit, 140 nests in 51 trees were counted. Many nests were still occupied by adults with chicks. Although two-thirds of the trees held one or two nests, three of the tallest (estimated at more than 30 m) trees held nine nests each.

39. Since the initial site visit occurred late in the season and the dense vegetation prevented accurate observation, it was not possible to determine the number of chicks fledged and gauge the productivity of this colony. Only three dead young were observed on the ground. Several adults and a few young were observed in the shallows around the perimeter of the island. By the time of the second visit in September all chicks had fledged and the nests were deserted. A red-tailed hawk (Buteo jamaicensis) was heard and observed over the colony during both visits.

Vegetation at the colony

40. The vegetation of the Fisher Island heronry was typical of the plant communities of other heron colonies studied in the Pacific Northwest (McMahon et al. 1974). The vegetation characteristics included an overstory of large nesting trees with an understory of dense shrubbery (Figures 6 and 7). In this colony, the dominant tree was black cottonwood. Intermediate and suppressed trees included red alder, Oregon

FIGURE 5. HERON COLONY CANOPY VEGETATION OF FISHER ISLAND


AND HERON
OW GROV

FIGURE 7. HERON COLONY UNDERSTORY VEGETATION OF FISHER ISLAND

ash, and Pacific dogwood. Table 4 summarizes tree species characteristics for black cottonwood, Oregon ash, and red alder. In each transect, black cottonwood accounted for more than 50 percent of the trees. Its average diameter (at breast height) was 0.59 m, coinciding with a mean height of approximately 29 m. Exceptionally large trees were measured at 1 m diameter breast height and had an estimated height of 32 m.

41. The shrubs and herbs in the understory were a mixture of native and introduced species (Table 5). Native red elder (Sambucus racemosa) and common snowberry accounted for a total of 12.8 percent of the understory cover and were observed in one-fifth of the quadrats, whereas the introduced black raspberry exhibited 1.7-percent coverage, but nevertheless occurred in 48 percent of all plots.

42. Perhaps the most significant understory plant within the Fisher Island heron colony was stinging nettle, an introduced herbaceous species. In July, this species accounted for only 7.2 percent of the understory cover; however, it was observed in 78 percent of the quadrats. This offensive perennial plant was estimated to have 156,000 stems per ha and accounted for 89 percent of all understory stems. Common snowberry, the species with the second most numerous stems, had a total of 14,000 stems per hectare and accounted for only 8 percent of total stems. Frequency of occurrence, number of stems per plant and plot, and average height of all herb, shrub, and young tree species are listed in Table 6.

43. Lichens, mosses, and ferns were commonly found growing in the fissures of the bark of live cottonwood, ash, and alder trees and on dead and decomposing logs and stumps of these species so prevalent throughout the understory. The most conspicuous mosses were stair step (Hylocomium splendens), feather (Eurhynchium oreganum), little shaggy (Rhytidiadelphus loreus), and juniper haircap (Polytrichum juniperinum). Licorice fern (Polypodium vulgare) frequently was observed growing on moss-covered tree trunks and rocks.

Table 4

Tree Characteristics of the Fisher Island Heronry

Species	Diameter*, cm Mean	Diameter*, cm Max.	Height, m Mean	Height, m Max.	No. of Nests Min.	No. of Nests Max.	No. of Nests Av.	Number of Trees Sampled
Black cottonwood	59.4	100	30.0	32	0	7	3.1	8
Oregon ash	18.2	30	13.0	16	--	--	--	4
Red alder	22.7	30	18.0	30	--	--	--	3

* At breast height

Table 5

Ground Cover of the Fisher Island Heronry

(from 0.5m^2 Plots)

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Herbs	Stinging nettle	200	7.2	0- 30	78
Shrubs	Red elder	83	8.5	0- 80	22
	Common snowberry	51	4.3	0- 80	19
	Black raspberry	66	1.7	0- 10	48
Other	Leaf litter	--	70.5	0-100	93
	Logs and twigs	--	15.6	0-100	70

Table 6

Understory Vegetation of the Fisher Island Heronry

(from 16m^2 Plots)

Life Form Species	Frequency	Percent of Total Life Form	Stems/ m^2	Stems/ Plant	Average Height (m)
Herbs					
Stinging nettle	100	100	15.62	1.5	--
Shrubs					
Common snowberry	88	80	1.35	3.8	2.5
Red elder	75	8	0.15	2.8	1.7
Black raspberry	38	7	0.14	2.0	2.0
Rose	13	5	0.13	9.0	2.0
Trees					
Oregon ash	38	29	0.02	--	--
Pacific dogwood	25	57	0.04	1.7	--
Red alder	13	14	0.01	--	--

Discussion

44. When the Fisher Island colony was visited in April 1977, U.S. Fish and Wildlife Service and Washington State Game Department personnel estimated 300 to 350 total nests in the colony (personal communication, 15 June 1977, Susan Saul, Public Use Specialist, U.S. Fish and Wildlife Service, Longview, Washington). Based on photographs taken during this visit, the absence of upper-story vegetation greatly enhanced the reliability of their field observations. The count in this study (140 nests), taken through dense foliage, was probably low, perhaps by as much as 100 percent. A 300-nest colony would make this one of the largest in Washington.

45. Previous studies of a 175-nest heronry on Karlson Island (Werschkul et al. 1977) at River Mile 26 in the Columbia showed that arrival time was in early February, and hatching activity peaked in mid-April and was completed by the end of May. This implies that most birds had arrived by mid-February and that fledging occurred in early July. Of the nests, 92 percent were active and a mean of 2.7 birds were fledged per successful nest. However, reproductive success of the great blue heron varies widely. Other studies on the west coast have reported a fledging success rate of 1.9 to 2.3 (Pratt 1972) and 2.61 (Henny and Bethers 1971).

46. Werschkul et al. (1977) also reported that 12 colonies studied, Karlson Island was the largest, had the earliest arrival date, and had the greatest fledging success. Whether the success of this colony was due to adequate food sources, the lack of human disturbance, or some other factor, it appeared that Fisher Island also exhibited these attributes and it is expected that productivity of this colony was very high. If it is assumed that 300 nests existed, 90 percent were active and fledging success was 2.5 birds per successful nest, the Fisher Island colony would have produced approximately 770 young.

47. Dredged material has not been deposited on this island, at least since 1930, and the colony is relatively insulated from human disturbance due to limited accessibility and lack of knowledge concerning its location. Recently, however, dredged material was deposited to the

south, forming a long "hook" (Hump Island) connected to Fisher Island. A recent study of other western Oregon heron colonies showed that the number of active nests in a colony was related to the average tree height within the colony and the size of the nearest estuary (Werschkul et al. 1977). Although the Columbia estuary provides considerable feeding and resting areas for herons, the decrease in nearby habitat represented by dredged material deposition northward to Fisher Island could reduce food resources for this colony and thus decrease colony membership.

48. The bay between Hump Island and Fisher Island was also used as a moorage area for log rafts which were used as resting areas by herons and other species of birds. Loss of these rafts on the south side of the island would probably result in heavier use of north channel rafts. This channel receives heavier traffic and birds here would be subject to more human disturbance.

49. The large sandy beach of Hump Island has been attractive for recreational use. It is expected that increased recreational use of this spit would result in more numerous human incursions into forest and grass-herb habitat near the colony. This could result in the abandonment of this nesting site due to excessive disturbance.

50. Many adequate nesting sites for this species are located in the Columbia Basin and numerous colonies have been identified. It is suggested that additional studies be undertaken to determine the relative value of this colony before steps are taken which would enhance or degrade the existing habitat.

Columbia River, Ryan Island

Physical characteristics

51. Ryan Island is located at River Mile 38 in the Columbia River near Cathlamet, Washington (Figure 3). The 78-ha island is approximately 2 km long and 0.5 km wide. In the northwest, the island gradually grades from river level to a low marsh and high marsh region 0.5 to 1 m above the water. An increase of an additional 1 to 2 m in height occurs between high marsh and adjacent shrub and forest zones.

52. The northern marshes of the island are frequently inundated, whereas the higher shrub and tree cover in the south is only flooded during extremely high water. A perched water table within centimeters of the soil surface exists below the island. From a major slough in the north, surface water is able to penetrate the interior and thus flood even the highest ground. A dense understory of horizontal stems, with their numerous branches and shoots growing vertically toward the canopy, forms a dense almost impenetrable environment.

53. The soils of Ryan Island are variable. Under densely vegetated and highly productive marsh vegetation, soils exhibiting an organic layer have developed, whereas under shrub and tree canopies sandy silts still dominate. Apparently, leaves of deciduous shrubs and trees are washed from the soil surface before they are adequately decomposed to become an integral part of the soil, thus contributing little to soil formation.

Habitat description

54. Of the four habitat types distinguished on this island, the forest and riparian shrub types were clearly distinguishable from both low and high marsh types (Figure 8). However, the gradation from high marsh to low marsh was subtle, especially within the northwestern slough area. Composition and relative density for the four habitat types on Ryan Island are shown in Appendix A, Table A2.

55. Low/high marsh. An extensive marsh habitat covered the northwestern one-third of the island. Although no special effort was made to characterize the vegetation of this area, some species were noted during visits to the heron colony. In addition, species composition was probably similar to that found in marshlands of other Columbia River islands. The high marsh apparently was dominated by Lyngby's sedge; however, uniform stands of cattail (Typha latifolia) also were abundant. Scattered throughout the sedge and cattail were stands of yellow flag (Iris pseudacorus) and white bog-orchid (Habenaria dilatata). The low marsh probably also was dominated by Lyngby's sedge.

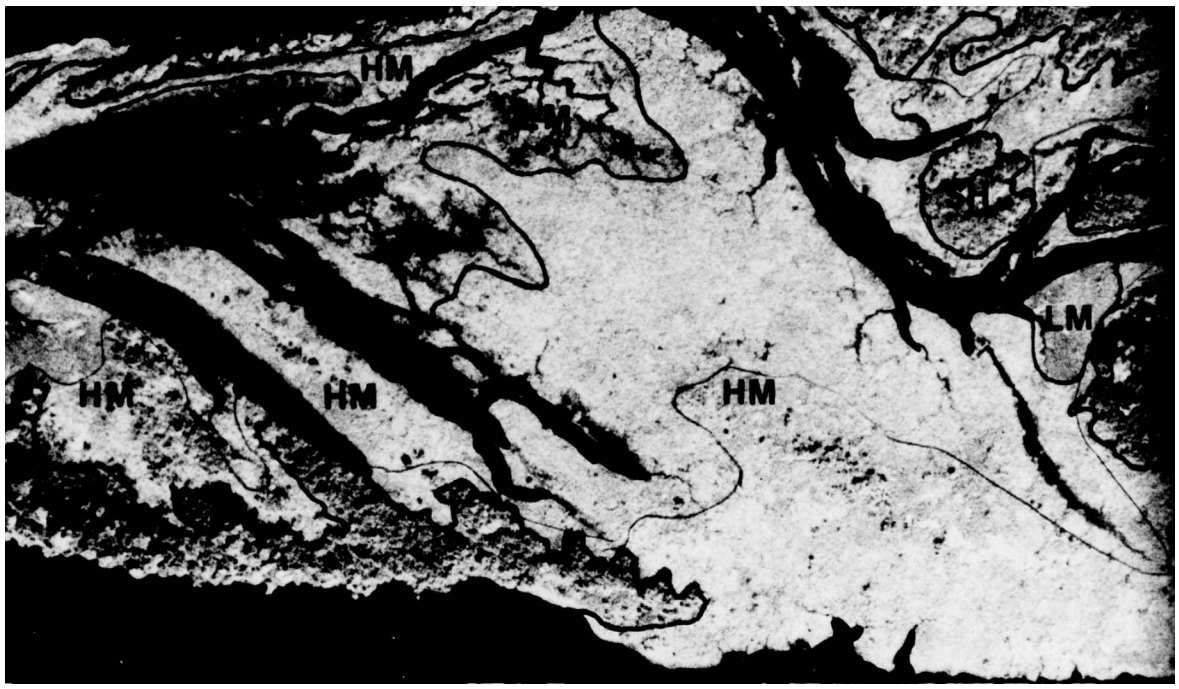
56. Shrub. A shrub community formed a transition habitat type between marsh, inland slough, and river environments and interior forests. Comprised primarily of immature willow, red alder, Pacific dogwood, and other riparian species, this habitat type formed a dense vegetation zone that protected the uplands from river currents and floods. Physical damage from floating logs and other debris was minimized.

57. Forest. Structurally, the seral forest community of Ryan Island was similar to that of Fisher Island. The forest was dominated by black cottonwood, although mature Sitka spruce (Picea sitchensis) occasionally was present. Common smaller trees and most saplings included willow, dogwood, and alder. A thick shrub understory was dominated by salmonberry (Rubus spectabilis), black raspberry, and common snowberry. Exceptionally wet areas were dominated by patches of skunk cabbage (Lysichitum americanum), Pacific water parsley (Oenanthe sarmentosa), and touch-me-not.

Colonial resting species

58. Extremely dense undergrowth blocked access to the colony, which was located near the center of the island in the tallest trees of the forest habitat. All the nesting trees comprised an area of approximately 0.6 ha, although the tallest trees in the northwest corner of the colony received heaviest nesting pressure (Figure 9). Only one adult was observed along the south shore of the island. While the colony was observed from the ground, very few young were seen in nests, although calls were heard from the marshy area to the north.

59. During the first visit in early July 50 nests in 16 trees were observed, although nest visibility was poor, as on Fisher Island. Only black cottonwood trees contained nests; approximately one-half of the trees held 1 or 2 nests, while one tree held 10. Two nests were found on the ground and no dead young were observed. Since the site was first visited late in the season, it was not possible to determine the status of nesting pairs, although some young were still in the nests. By the time of the second visit in September the nests were deserted.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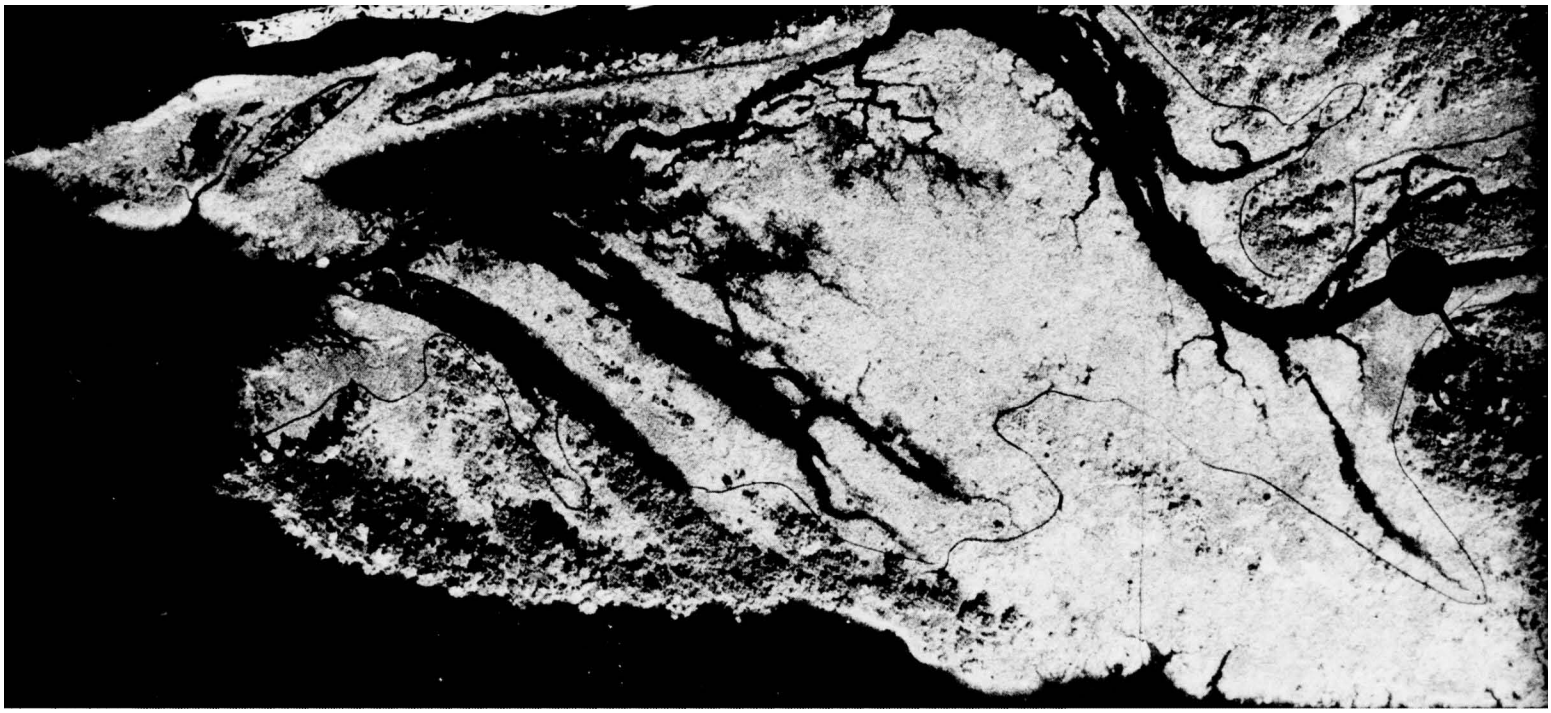

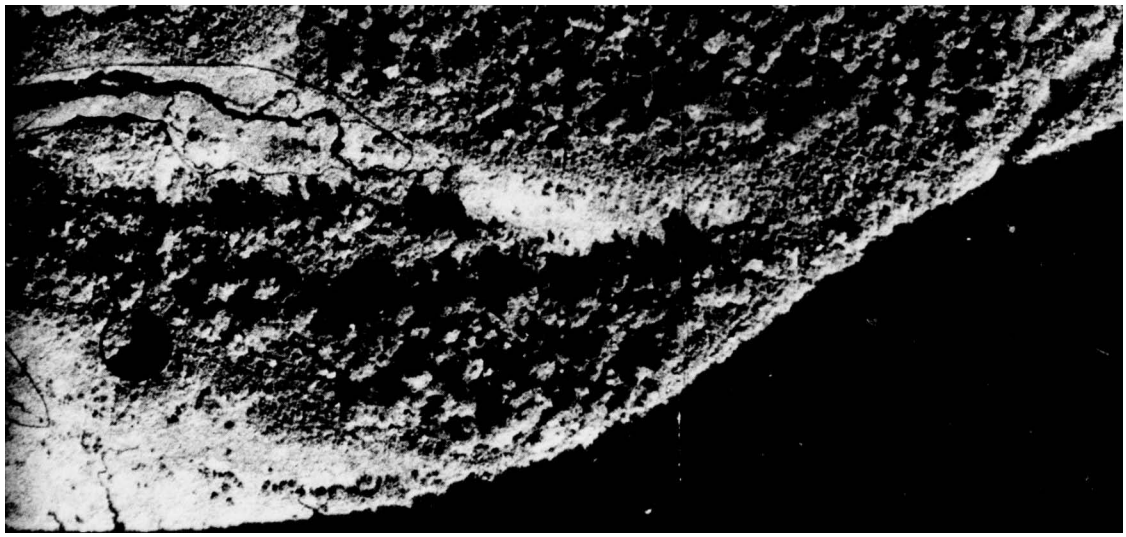

Vegetation at the colony

60. The vegetation of the Ryan Island heron colony was similar in appearance to that shown in Figures 5 and 6. Although black cottonwood, red alder, Oregon ash, and Sitka spruce were found within the colony, cottonwood was ecologically dominant (Table 7). This species was taller (33 m average) and wider at 0.51-m breast height than the other three species. Alder, although equally common, was a subordinate and significantly smaller (16-m height and 0.27-m breast height). Both ash and spruce rarely occurred in the forest canopy.

Table 7

Tree Characteristics of the

Ryan Island Heronry

Species	Diameter, cm		Height, m		Number of Trees
	Mean	Max	Mean	Max	
Black cottonwood	50.9	120	33.0	40	11
Red alder	27.0	40	16.0	25	10
Oregon ash	22.0	30	20.0	20	2
Sitka spruce	--	30	--	15	1

61. In order of decreasing frequency of occurrence, the following species were also found in the herbaceous layer: touch-me-not, 8 percent; Pacific water parsley, 6 percent; cattail, 3 percent; rose, 3 percent; and aster, 3 percent (Table 8). Nevertheless, dead organic matter covered much of the forest floor. Leaf litter and dead logs and twigs each accounted for 27 percent cover and ranged from zero to at least 80 percent. Bare ground, on the other hand, occurred in only 3 percent of the plots and at most accounted for only 5 percent of any sample plot.

62. As shown in Table 9, the understory was a mixture of several herbs and shrubs with an occasional young tree. Salmonberry was by far the most abundant understory species; it accounted for 33 percent of the cover and occurred in 81 percent of the 0.5-m^2 plots (Table 8) and in 100 percent of the 16-m^2 plots (Table 9). Black raspberry and common

Table 8

Ground Cover of the Ryan Island Heronry

(from $0.5m^2$ Plots)

Life Form	Species	Importance Value	Percent Cover* Mean	Range	Percent Frequency
Herbs	Pacific water parsley	115	3.6	0- 80	6
	Touch-me-not	60	0.6	0- 10	8
	Cattail	25	0.3	0- 10	3
	Aster	--	--	0-T	3
Shrubs	Salmonberry	144	33.6	0-100	81
	Black raspberry	27	5.3	0- 95	19
	Common snowberry	26	3.5	0- 30	22
	Rose	3	0.1	0- 5	3
Trees	Pacific dogwood	178	2.5	0- 40	14
	Pacific nine-bark	22	0.1	0- 5	3
Other	Logs and twigs	--	27.9	0- 80	69
	Leaf litter	--	27.6	0- 95	67
	Bare ground	--	0.1	0- 5	3

* T: Trace

Table 9

Understory Vegetation of the Ryan Island Heronry

(from 16m^2 Plots)

Life Form Species	Frequency	Percent of Total Life Form	Stems/ m^2	Stems/ Plant	Height (m)
Ferns					
Sword fern	11	100.0	0.01	1.0	0.5
Shrubs					
Salmonberry	100	72.3	2.56	4.0	2.2
Black raspberry	56	9.3	0.33	2.0	4.0
Common snowberry	33	18.1	0.64	3.0	2.0
Rose	11	0.3	0.01	--	--
Trees					
Pacific dogwood	22	81.8	0.27	--	--
Vine maple	11	6.0	0.02	--	--
Hawthorn	11	6.0	0.02	--	--
Cascara	11	3.0	0.01	--	--
Sitka spruce	11	3.8	0.01	--	--

snowberry accounted for 5.3 and 3.5 percent cover, respectively, but were scattered, appearing in only approximately 20 percent of the 0.5-m^2 plots. A count of 2.6 salmonberry, 0.3 raspberry, and 0.6 snowberry plants per m^2 indicates the density of the understory of these shrub species. Combined with 0.27 dogwood stems per m^2, the majority of understory species equals 3.8 stems per m^2 (Table 9).

Discussion

63. Ryan Island was first considered for this study following information that nests had been sighted earlier (personal communication, 15 May 1977, Robert Watson, Refuge Manager, Lower Columbia River, U.S. Fish and Wildlife Service, Longview, Washington; personal communication, 16 May 1977, Scott English, Wildlife Biologist, U.S. Fish and Wildlife Service, Portland, Oregon). Numerous other islands along the Columbia River also were reportedly used by nesting herons. An extensive aerial search from River Mile 32 to 60 revealed heronries only on Ryan and Fisher Islands. The number of nests observed on Ryan Island during this study greatly exceeded the number previously reported. This illustrates that systematic observations using reliable techniques are required to determine the location and general characteristics of all Columbia River colonies before any definitive research can be undertaken on individual colonies.

64. It must be assumed, due to the dense foliage, that the count of 50 nests during this study substantially underestimated the actual number of nests in the colony. Given the information available for the Fisher Island colony described previously, the true number of nests could approach 100 on Ryan Island. It is expected that this colony was at least as productive as that described on Karlson Island by Werschkul (1977), since it was as remote and near an adequate food supply. Given these parameters, it is possible that total production of fledged young could have approached 250.

65. U.S. Army Engineer, Portland District, records indicated no history of dredged material disposal on the island. The colony appeared to be fairly productive and additional nest trees were available for

colony expansion if inaccessibility and an adequate food supply are maintained.

Baker Bay, East Sand Island

Physical characteristics

66. As shown in Figure 10, East Sand Island is located near the mouth of the Columbia River. Although closer to the Washington shore, East and West Sand Islands are actually within the State of Oregon, since the state boundaries were established along the Columbia River navigation channel, which once passed north of the islands. The two islands were originally joined, but were separated by a storm in 1932. Various attempts were made to rejoin the islands to prevent further channel migration and erosion. In 1943, another storm breached the island. In 1950 stone fill was placed on the western end of East Sand Island to prevent loss of the existing groin and the island. The groins extending from the island are now maintained to prevent northerly shifts of the deep water channel of the Columbia River.

67. The island is uninhabited, but was used extensively as a shore base for the Columbia salmon fishery in the early 1900's. The ruins of rail beds and several structures still exist. Waterfowl hunting occurs in the fall, and several navigational aids on the island are maintained by the Coast Guard. Human recreational use is believed to be very low, due to the difficulty of beaching small craft on the exposed coast and the large expanse of tidal flats which must be crossed on the sheltered coast.

68. The south shore is directly exposed to the currents of the Columbia River and is subjected to the wind, weather, waves, and tides of the Pacific Ocean. A typical coastal sand beach has become established along the shore except where stone rubble has been placed for stabilization. The elevation of the north shore decreases gradually to the intertidal sand flats typical of many estuarine islands in the Northwest. The shallow waters of Baker Bay (about 1.5-m at mllw) reduce the effects of tidal currents and wind waves on this coast.

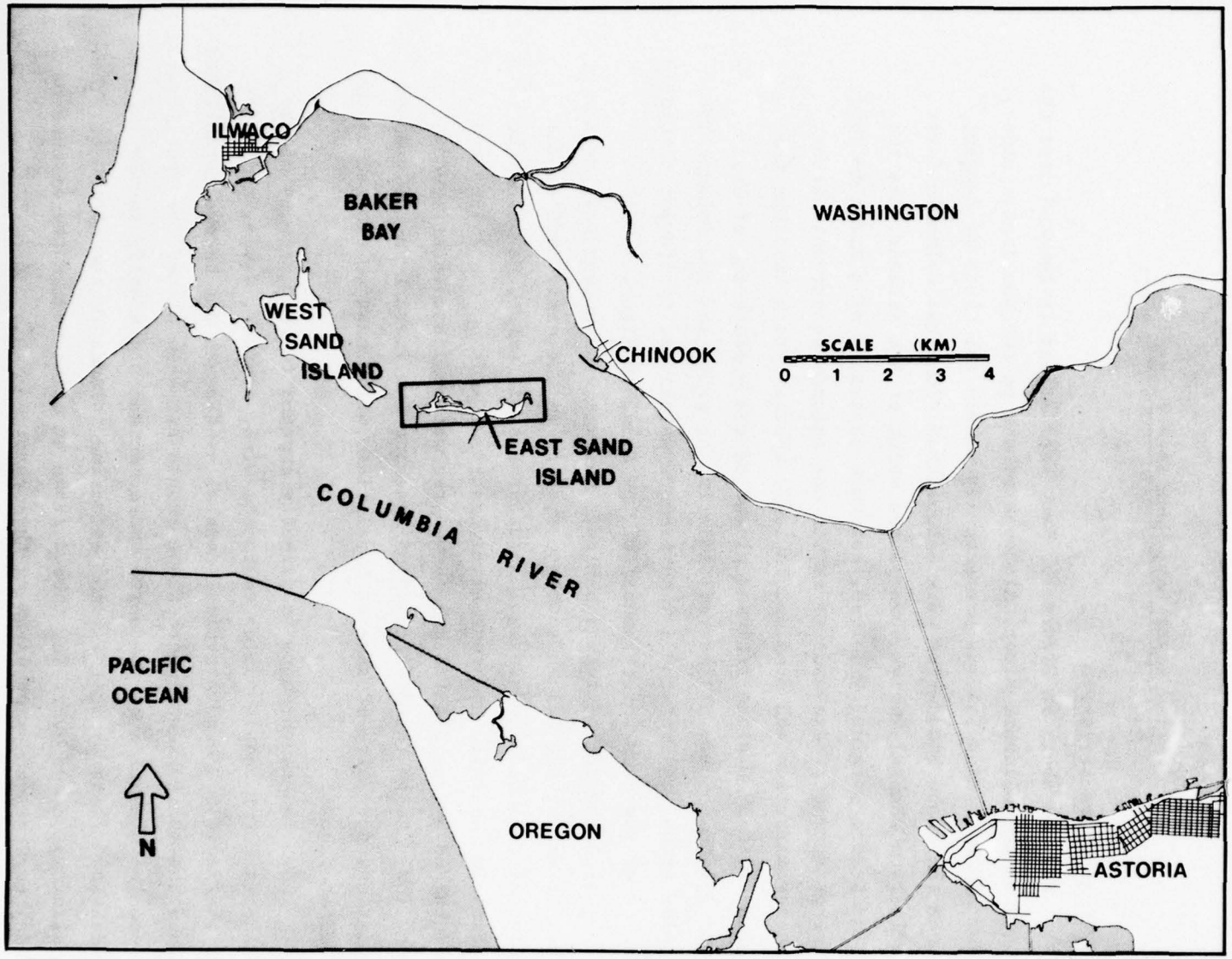

FIG.10 BAKER BAY STUDY AREA

69. In 1977, the island was approximately 1800 m long, 265 m wide at its narrowest point, and covered 44 ha. The broadened eastern and western ends were somewhat isolated since they were separated by a long, narrow central section. The major habitats occurred within the enlarged ends of the island, while the central section was characterized by grassland and intertidal marsh.

70. The highest point on the island was the apex of the ridge along the southwest margin of the island which extended into Baker Bay as a jetty. The elevation increased rapidly on the west side, the distance between mhhw and the ridge varying between approximately 3 and 10 m. Inland, with the exception of a second lower and shorter driftwood hummock ridge that paralleled the rock ridge, the topography gradually sloped toward the north. Rolling terrain extended to the sand flats on the north side of the island. Within this lowland region, tides and local ponding influenced colonizing vegetation.

71. Soils of the beach, dunes, and most of the exposed terrestrial habitats were pure sand, whereas soils of the terrestrial protected sites, although underlain by sand, contained a litter layer and an organic-sand mixture of variable depth. Soil of the lowland marsh habitats varied with the topography, although organic silts and sands were major components.

Habitat description

72. Eleven habitat types within the intertidal and upland portions of the island were differentiated (Figure 11). These habitats were characterized by varying combinations of topography, exposure, and human intervention which have influenced the growth of vegetation communities. These habitats are discussed in the following paragraphs with regard to their vegetative associations and their use by seabirds. Composition and relative density of observed vegetation in each habitat type are shown in Appendix A, Table A3.

73. Beach. Beach habitat was primarily located along the southern shore, with scattered smaller areas of accretion occurring along the northwestern shore. Plant communities in this habitat were low both in

species diversity and number. Salt spray, soil porosity and temperature extremes curtail colonization by plants which cannot tolerate these hardships. Existing plants were ephemeral because of daily and seasonal inundation, although a few species have become successfully established in saltspray zones and on periodically flooded and shifting sands. Foremost among these were American dunegrass (Elymus mollis), American searocket (Cakile edentula), and yellow abronia (Abronia latifolia).

74. Stone rubble. The stone rubble habitat was created to arrest island erosion and migration. It formed a narrow band approximately 10 m wide that extended along the northern margin of the island and along both flanks of the jetty. This habitat was covered by daily tides and was subjected to intensive wave action. No soil was observed, nor was there any sign of rooted vegetation. The rocks did, however, contain substantial quantities of drying and rotting drift line vegetation including eelgrass (Zostera marina), sea lettuce (Ulva lactuca), and other marine algae.

75. Sand flats. During low tides, extensive sand flats were exposed in sheltered locations surrounding the island. Floating aquatic vegetation and detritus were abundant. The largest flat was a shallow underwater extension of the island's west margin. Occasionally, this flat became completely exposed, which provided food for wading birds and shorebirds. In general, this flat received heavy use during good weather. The smaller and more protected flats within the northwest projection and the northeast jetty provided more shelter and were more heavily used by birds during inclement weather and rough seas.

76. Storm tide plain. On the southeastern and southwestern sections of the island, storm tides had deposited driftwood far up on the beach so that it no longer was subjected to tidal influence and had been stable long enough to allow sand accretion. On this plain, widely scattered driftwood provided a protected microhabitat and enough stability for the successful colonization of dunegrass and searocket. This in turn provided stability for other successional species.

77. Dune. Dune habitat was observed along the east and west ends of the island and existed as a narrow but distinctive dunegrass-covered


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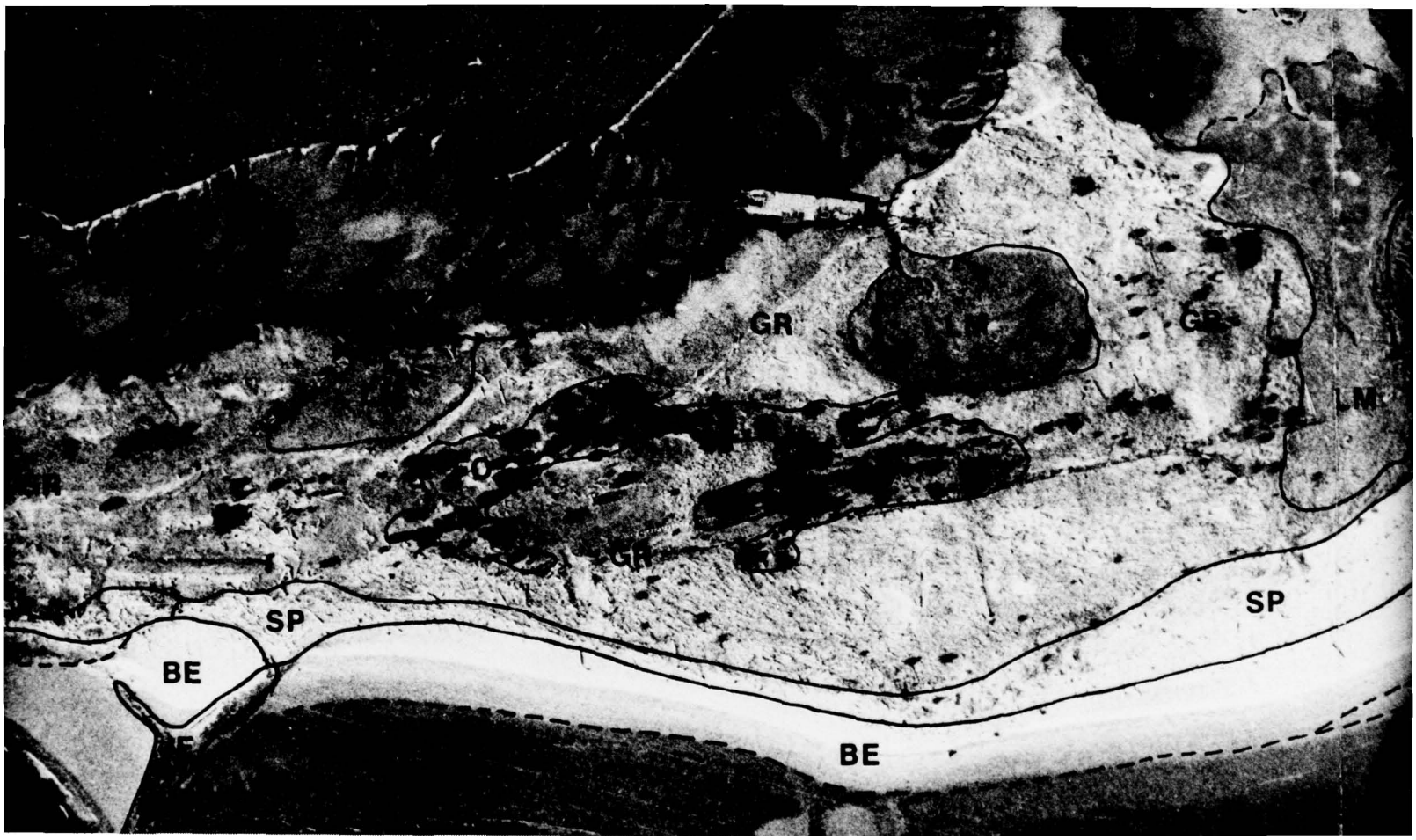
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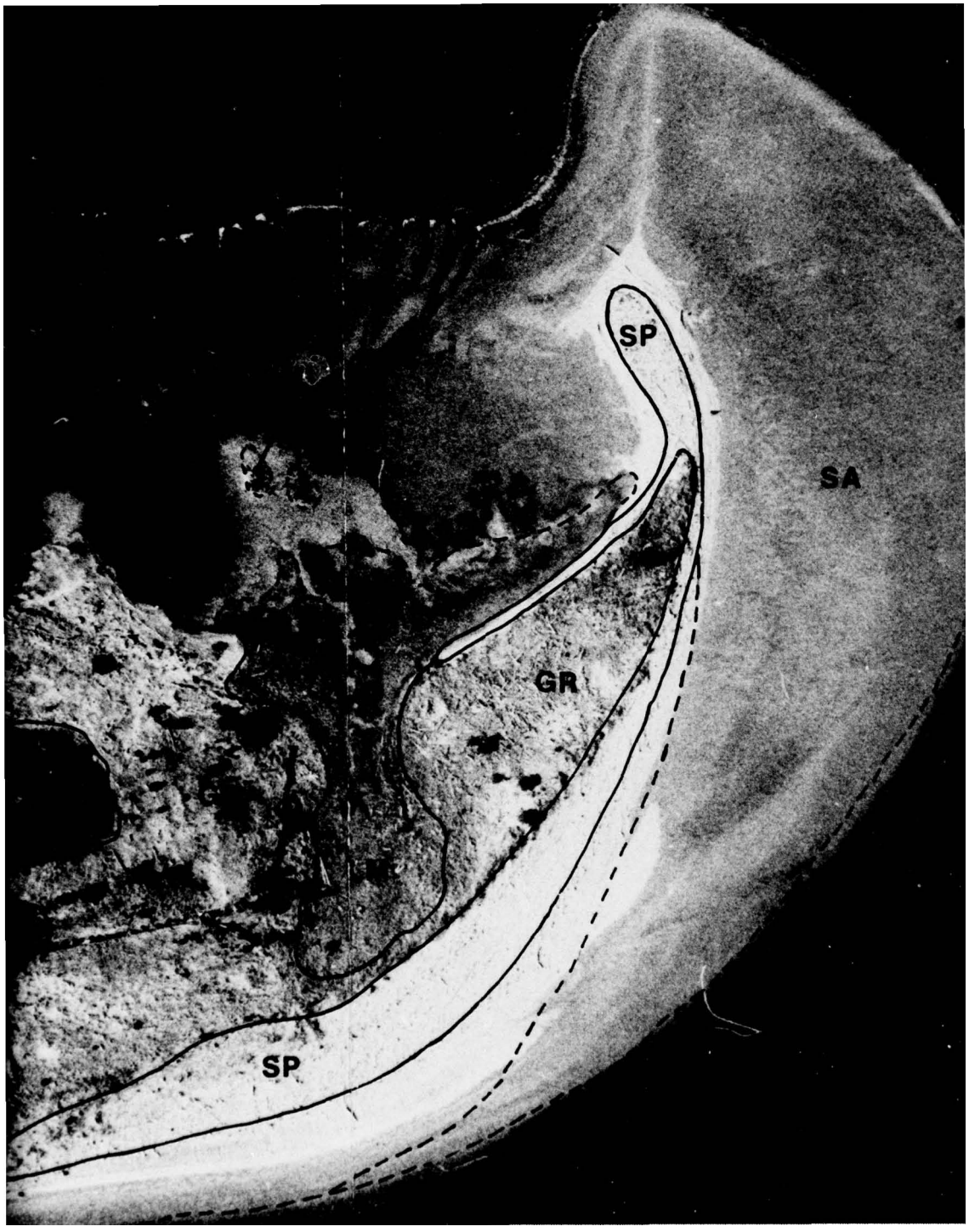
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coastal ridge between beach and grass-herb habitats. The stabilized dune, with its dense dunegrass community, significantly protected the adjacent grass-herb habitat from wind and saltspray. Although dunegrass was the most abundant species, red fescue (Festuca rubra), beach pea (Lathyrus japonicus), and searocket were also important components of this habitat.

78. Driftwood hummock. The driftwood hummock habitat was one of the ecologically most important habitats on the island. Extending as two 10-to 20-m parallel bands along the length of the western arm, the hummock configuration provided stability and diversity for a wide range of physical and biological processes. Protected from wind and erosion, sand and organic matter lodged between adjacent and overlapping logs accumulate and form soil. Within these protected locations occurred the herbs yarrow (Achillea millefolium), dune tansy (Tanacetum douglasi), and California figwort (Scrophularia californica), and the shrubs Scotch broom (Cytisus scoparius) and coast red elder (Sambucus racemosa var. arborescens). Numerous other species successfully colonized hummocks; however, species distribution within hummocks appeared fortuitous. Some vertical stratification of vegetation may have occurred with shrubs colonizing higher and leeward hummock localities, but this observation was not rigorously tested.

79. Grass-herb. The grass-herb community covered most of the level uplands that extended from the eastern to western margins of the island. This vegetatively uniform habitat was comprised primarily of perennial grasses, including red fescue, tufted hairgrass (Deschampsia cespitosa), creeping bentgrass (Agrostis alba), and a species of bluegrass (Poa sp.). A wide variety of herbs were scattered throughout this region, but only sandmat (Cardionema ramoissima) was of any compositional significance.

80. Grass-herb driftwood. Within the grass-herb zone were areas of scattered driftwood logs abundant enough to be of significant importance to gull nesting. Plant species similar to those found in the grass-herb habitat were present.

81. Forest. The forest habitat existed as scattered clumps of Sitka spruce on the western highlands of the island. Trees averaged 10 m in height and were estimated to be 50 years old. Smaller younger spruce occurred near the periphery of mature tree clumps, suggesting that some regeneration had occurred. The understory of this habitat type was a mixture of perennial grasses, the most common being fescue. A few perennial herbs were scattered throughout the site, but were not a significant component of this habitat.

82. Jetty. The jetty was an important man-made habitat since it protected the vulnerable shoreline from wave and wind action and provided a unique habitat for breeding gulls. The jetty was characterized by the presence of two plant species, giant vetch (Vicia giganteum) and figwort. Other rooted vegetation was absent, although dead and decomposing vegetation remained from winter storms.

83. Low marsh. Low marsh habitat extended along the entire northern perimeter of the island. It was a vegetatively simple habitat influenced by daily tidal fluctuations. In the northeast, it covered a large portion of the island, almost separating the eastern tip from the western uplands. The marsh appeared to be colonizing shallow areas of the bay where sand and silt had accreted. The eastern section of the island contained the greatest area of marsh, which decreased to the west. Vegetation of this region consisted primarily of circular clumps of arrowgrass (Triglochin maritima) and pickleweed (Salicornia virginica), characteristic of low marshes throughout Pacific Northwest estuaries. A second but smaller low marsh habitat was located in the island's northwest section. This marsh was less frequently submerged than the other and was comprised primarily of Lyngby's sedge and Pacific silverweed (Potentilla pacifica).

84. Summary. Eleven habitat types within the intertidal and upland portions of the island were differentiated. Low marsh, beach, and grass-herb were the three most extensive habitat types. Although the driftwood hummock habitat was well-defined just inland of the exposed coasts, hummocks to the north were widely dispersed throughout low marsh and grass-herb communities. Driftwood was scattered throughout the

western portion of the island and did not form a clearly defined habitat, although it collectively was an important component of sheltered sites.

Colonial nesting species

85. Nesting areas for colonial seabirds were identified as shown in Figure 12. The only species of seabird observed to nest on this island was the western/glaucous-winged hybrid gull (Larus occidentalis/L. glaucescens), which in this area appeared to exhibit more morphological traits of the western gull than of the glaucous-winged gull. Various gradations of the hybrids, ranging from the slightly gray mantle of the glaucous-winged gull to the totally dark back of the almost pure western gull, nested throughout the colony.

86. The colony was first visited 21 June, too late in the season to accurately establish pairing, egg-laying, and incubation times. Although gulls nested from the center of the island westward, some habitats were preferred over others and had greater concentrations of nests. To determine the breeding population, nests were counted in eight areas within the primary, secondary, and tertiary nesting areas shown in Figure 12. The eight areas were selected on the basis of topographic and vegetative homogeneity to ensure that the sampled area would accurately represent the total. For each area, an estimate was made of the number of nests not found, which ranged from 0 to 50 percent, depending on density of cover. The proportion of the sampled area relative to the total area was also determined, which varied from 10 to 100 percent. During this visit, 171 active nests were counted. Allowances for representative sampling and nests not observed resulted in an estimate of approximately 620 active nests on the island, or a population of about 1240 breeding birds. Counts from photographs of undisturbed birds near nests substantiated this estimate.

87. The highest concentration and greatest number of nests were found in the grass-herb area east of the dune at the western end of the island (shown in Figures 13 and 14). Over 60 percent of the total nests were located here, in an area of 1.3 ha. The greatest number of nests were found near large driftwood logs 20 to 60 cm in diameter which were

scattered throughout the area. Distance between adjacent nests was difficult to determine with confidence since the dense vegetation precluded the definitive location of every nest. The average inter-nest distance in this area was approximately 6 m, although nests were as close as 0.5 m when separated by driftwood.

88. During the 21 June visit, the number of eggs and young of 269 nests were recorded throughout all major vegetative types used by the colony (Table 10). Over one third of the nests were empty. Of the 171 active nests, 20 percent contained chicks and no eggs, 66 nests (39 percent) still held three eggs and were being incubated, and the other nests were in some stage of hatching. The total production of the active nests was 310 eggs and 103 chicks, resulting in a mean clutch size of 2.4 eggs per nest. The actual clutch size was probably closer to three per nest, since chicks which were old enough to leave the vicinity of the nest were not counted.

Table 10

Gull Nest Status on East Sand Island

21 June 1977

Number of Eggs and Chicks per Nest	Number of Chicks per Nest			
	0	1	2	3
0	98	9	15	11
1	14	4	9	1
2	36	6	0	0
3	66	0	0	0

Total Nests	269
Active	171

89. Many chicks were observed running through the dense vegetation of the colony and care was required to avoid stepping on the young birds. Several nests and many chicks were seen on the sand beach. Some harassment of fleeing chicks by adult gulls occurred, but no overt

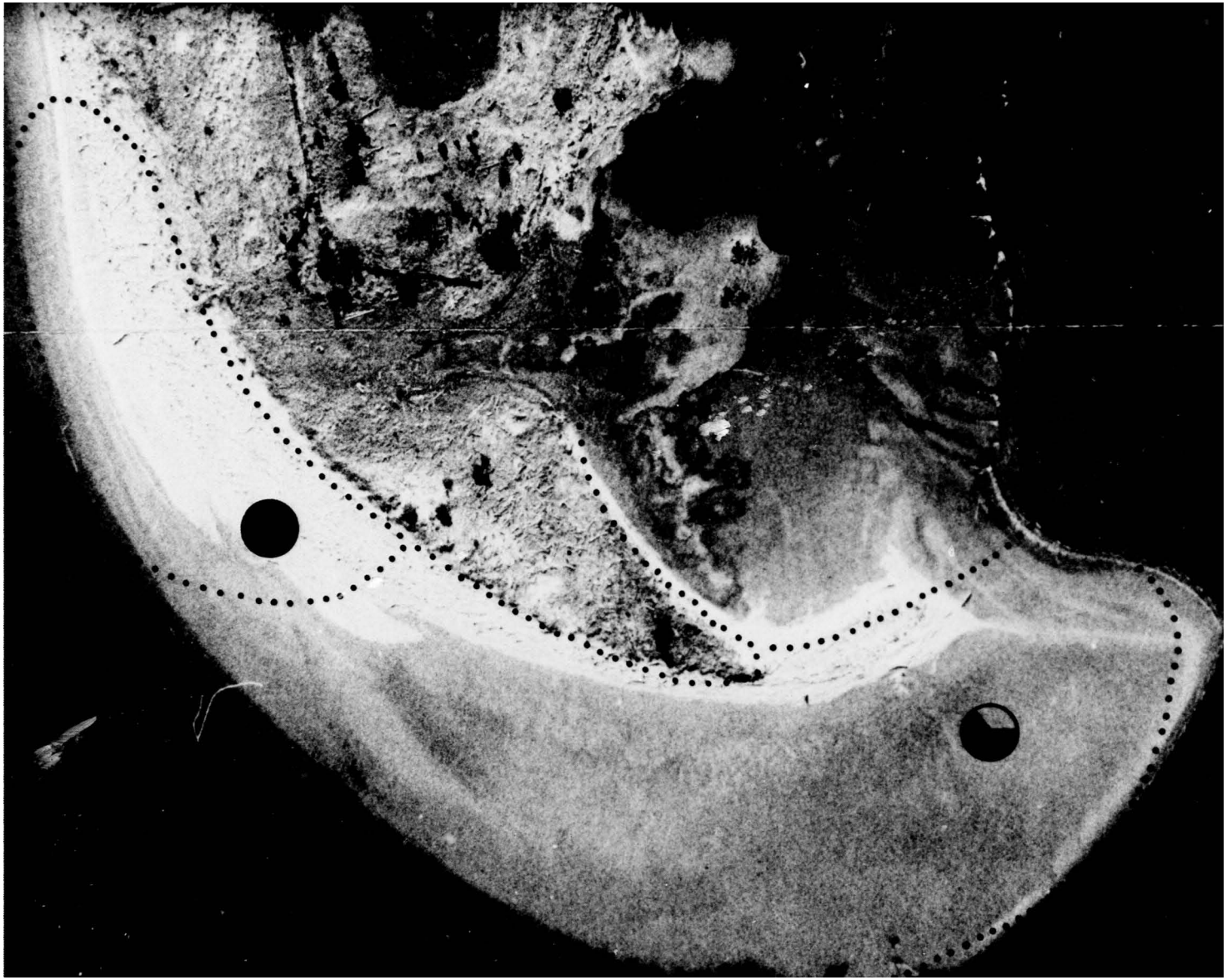


FIGURE 13. GULL COLONY OF EAST SAND ISLAND, VIEW TO THE NORTHEAST FROM THE WEST EDGE OF THE COLONY

FIGURE 14. GULL COLONY OF EAST SAND ISLAND, VIEW TO THE SOUTHEAST FROM THE WEST EDGE OF THE COLONY

predation was observed and only three or four dead chicks throughout the colony were found.

90. A total of 56 nests was observed among the large rocks of the jetty extending westward from the west end of the island. This habitat was almost devoid of vegetation and nests were usually located adjacent to large driftwood logs or in sheltered areas between rocks. The nests were composed of grasses from the grass-herb habitat type in addition to mosses, sea lettuce, and eelgrass.

91. The driftwood/hummock habitat type appeared to be the most popular nesting area. Groups of large storm-tossed logs, sometimes piled to heights of 2 m and interspersed with shrubs, were the first areas repopulated following colony disturbance. Approximately 50 percent of the nests observed in these areas on 22 June were empty and had been active, indicating that hatching was complete. Since the percentage of hatched nests was greater than that of all other habitats, it was assumed that the driftwood/hummock areas were colonized first and thus represented preferred nesting habitat.

92. During the first June visit, 11 nests were marked in each of the grass-herb and rock jetty habitats. All marked nests contained three eggs and were examined during the second visit 1 week later on 30 June. Results are shown in Table 11. If it is assumed that egg-laying was completed by 21 June, then the three-egg nests (unhatched) represented 36 and 52 percent of the total nests in the grass-herb and rock jetty habitats, respectively. One week later, 13 of the 22 marked nests had hatched. Twice as many unhatched nests were found on the jetty as within the grass-herb habitat. Three of the marked nests had been abandoned.

93. A final visit was made to the island in mid-August. All chicks had fledged and were located in large creches in the west cove between the jetty and the dune. While traversing the nesting area, four dead chicks were observed and two injured young were also seen which probably did not survive to fledge.

Table 11

Analysis of Nests Marked in Two Habitat Types on East Sand Island

	June 22		
Habitat Type	No. of 3-Egg Nests	Percent 3-Egg Nests	No. of Marked 3-Egg Nests
Grass-Herb	25	36	11
Rock Jetty	17	52	11

	June 30		
Habitat Type	No. of Marked 3-Egg Nests	Percent Marked 3-Egg Nests	No. of Marked Nests that were Abandoned
Grass-Herb	2	18	1
Rock Jetty	4	36	2

Vegetation of the colony

94. On East Sand Island, gulls nested in several structurally and vegetatively discrete habitats: dune, grass-herb, driftwood hummock, and jetty. The driftwood hummock and jetty habitats had sparse vegetative cover and were clearly different from dune and grass-herb areas. The jetty was colonized by two plant species, giant vetch and California figwort, but existed mostly as a large quarried rock pile. The driftwood hummock, although exhibiting a wide variety of grasses, herbs, and shrubs, particularly toward the lowland grass-herb fringe, was primarily a vegetation-free nesting site of driftwood logs and debris.

95. One transect through each of the four colony habitats was analyzed with regard to species composition (Figure 12). A quantitative analysis of plant transects across the dune, driftwood hummock, driftwood, and grass-herb nest localities revealed vegetative and structural similarities. Grasses were the most important component when measured by both the percent cover and frequency of occurrence (Tables 12 through 15). American dunegrass was the predominant species on hills and knolls, exhibiting more than 50 percent cover within elevated plots and accounting for 25, 41, 2, and 6 percent of the cover in all four transects. Within the gently contoured interior plain of the island, red fescue was the primary grass component. Bluegrass, tufted hairgrass, common velvetgrass (Holcus lanatus), and cheat grass (Bromus tectorum), although scattered widely throughout the colony, had a coverage of less than 5 percent.

96. The dominant herb throughout the grass habitat of the colony was sandmat. It covered a maximum of 40 percent of a plot and occurred in 57 percent of the plots sampled in the grass-herb driftwood area. However, within the interhummock lowland area (trough) of this area, its coverage increased to 66 percent and frequency of occurrence increased to 92 percent. The remainder of this species in the colony first appeared in the transition zone where dense dunegrass gave way to bluegrass and fescue, and then occurred scattered throughout the colony among the grasses. It grew as a dense impenetrable mat and successfully excluded the introduction of other species.

Table 12

Dune Habitat Vegetation in the Gull Colony of East Sand Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	American dunegrass	75.8	24.7	0-100	83
	Bluegrass	34.2	16.1	0-100	22
	Red fescue	37.4	12.8	0-100	39
	Rye brome	27.6	9.7	0- 90	28
	Tufted hairgrass	12.9	3.3	0- 30	17
	Common velvetgrass	12.1	1.1	0- 10	22
Herbs	Purple cudweed	89.4	5.7	0- 40	39
	Sandmat	76.2	4.2	0- 20	39
	English plantain	34.4	1.4	0- 10	22
	Yellow abronia	--	--	0-T	6
	False dandelion	--	--	0-T	6
	Beach pea	--	--	0-T	6
	Seashore lupine	--	--	0-T	6
	Unidentified composite	--	--	0-T	6
Other	Litter	--	8.3	0- 30	39
	Bare ground	--	2.2	0- 15	28
	Logs	--	0.8	0- 15	22

* T: Trace

Table 13

Grass-Herb Habitat Vegetation in the Gull Colony of East Sand Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	American dunegrass	118.9	40.9	0- 95	91
	Red fescue	67.3	21.8	0- 80	55
	Tufted hairgrass	6.9	0.9	0- 10	9
	Bluegrass	6.9	0.9	0-100	9
Herbs	English plantain	113.0	21.8	0- 30	91
	Sandmat	45.7	10.9	0- 80	27
	Purple cudweed	24.5	3.2	0- 15	27
	Beach pea	16.8	0.4	0- 15	27
	Yarrow	--	--	0-T	9
	Sheep sorrel	--	--	0-T	9
	Unidentified composite	--	--	0-T	9
Other	Matted grass	--	17.7	0- 80	55
	Logs	--	2.7	0- 30	9
	Bare ground	--	0.9	0- 10	9

* T: Trace

Table 14

Grass-Herb-Driftwood Habitat Vegetation in the Gull Colony of East Sand Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	Red fescue	98.1	8.3	0- 40	52
	American dunegrass	37.4	2.4	0- 30	26
	Common velvetgrass	27.2	2.0	0- 95	17
	Tufted hairgrass	20.7	1.5	0- 25	13
	Bluegrass	16.7	0.9	0- 10	13
Sedges	Lyngby's sedge	200.0	0.4	0- 10	4
Herbs	Sandmat	124.5	40.2	0-100	57
	Pacific silverweed	12.0	2.8	0- 65	9
	Yarrow	27.3	2.0	0- 30	35
	English plantain	12.5	0.6	0- 10	17
	Unidentified composite	12.1	0.4	0- 5	17
	Purple cudweed	11.6	0.2	0- 5	17
	Field milkthistle	--	--	0-T	4
	Yellow abronia	--	--	0-T	9
Other	Logs	--	21.7	0- 65	61
	Litter	--	17.8	0- 75	48
	Bare ground	--	0.9	0- 15	13

* T: Trace

Table 15

Driftwood-Hummock Habitat Vegetation in the Gull Colony of East Sand Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Mosses	Fern	--	--	0-T	4
Grasses	Tufted hairgrass	63.7	19.4	0- 95	33
	Red fescue	55.9	15.4	0-100	33
	Common velvetgrass	41.5	9.6	0- 95	29
	American dunegrass	35.4	6.5	0- 50	29
	Silver hairgrass	3.5	0.2	0- 5	4
Herbs	Sandmat	76.3	13.7	0-100	25
	English plantain	44.4	4.0	0- 70	33
	Yarrow	52.2	4.0	0- 40	42
	Giant vetch	13.7	1.7	0- 40	8
	California figwort	6.6	0.8	0- 20	4
	Ragwort	6.6	0.8	0- 20	4
	Field milkthistle	--	--	0-T	4
Shrubs	Furze	200.0	0.2	0- 5	4
Other	Matted vegetation	--	25.0	0-100	42
	Logs	--	11.9	0-100	25
	Rocks	--	7.7	0- 90	13
	Bare ground	--	0.6	0- 15	4

* T: Trace

Discussion

97. Although the breeding chronology of gulls in this area has not been published, it was possible to estimate the nesting phase of East Sand Island gulls. Previous work has shown that the peak hatching period for western gulls in southern California is complete by 1 July (Schreiber 1970, Harper 1971, Hunt and Hunt 1976), so hatching was probably well underway on East Sand Island by 22 June.

98. It was assumed that nests with only one egg had hatched at least one chick which had deserted the nest and was not observed. The proportion of two-egg clutches for the glaucous-winged/western gull is not known, but may be inferred from other reports. Schreiber (1970) and Hunt and Hunt (1976) reported 10 and 20 percent two-egg clutches, respectively, for western gulls nesting in the California Channel Islands. Patten (1974) found that a maximum of 10 percent of the active nests of glaucous-winged gulls in southeast Alaska consisted of two-egg clutches. If it is assumed that 10 percent of the East Sand Island nests were two-egg clutches and had still not started to hatch, this would account for 17 of the 36 nests containing only two eggs on 21 June (Table 10). Excluding these 17 nests and the 66 nests with three eggs, a total of 88 out of 171 or 52 percent of the active nests had started to hatch. Thus, 21 June was very near the midpoint of hatching activity for the glaucous-winged/western gull on East Sand Island in 1977. Corroborating this are the data in Table 11, which show that at least 60 percent of the marked three-egg nests had hatched 1 week later.

99. Allowing for an incubation period of 26 days (Schreiber 1970, Harper 1971, Patten 1974), the mean date of egg-laying would be 26 May. The nesting period was also reported by these authors to be 40 to 45 days. Given a mean hatching date of 20 June on East Sand Island, the young would have fledged around 3 August, which agrees with the observations reported during the final visit of 12 through 15 August.

100. The 98 empty nests found during the 21 June visit represented 36 percent of the total constructed. Some may have contained chicks which deserted and were not observed. However, Harper (1971) reported 30 and 55 percent inactive nests of western gulls in California and Patten

(1974) found that 57 percent of glaucous-winged gull nests were inactive. It is therefore doubtful that many of the 36 percent observed on East Sand Island represent nests which had hatched.

101. It did not appear that specific nesting areas were chosen with regard to certain vegetation types. Rather, preferred nesting sites seemed to be located near randomly strewn driftwood in the grass-herb habitat or within storm-tossed piles of debris termed in this study driftwood/hummocks. Inter-nest distances were generally much less in driftwood areas, probably because views of adjacent nests were obscured.

102. The rock jetty represented a rather unique nesting habitat on East Sand Island, although the rocky habitat more closely approximated natural nesting areas on offshore islands. Table 11 shows that on 22 June, 52 percent of the jetty nests still contained three eggs, compared with 36 percent in the grass-herb area. Thus, it appeared that nesting occurred later on the jetty; additional work on this island could show whether the jetty is preferred or of secondary importance to the grass-herb area. This could provide information concerning the relative importance of dredged material disposal sites as nesting areas in this region.

103. Knowledge of this colony is not widespread. Tabor (1976) reported that a colony of 360 to 520 pairs of glaucous-winged gulls nested on the island in addition to 540 to 780 pairs of western gulls. It is not now possible to clearly distinguish between the two species. Given our estimate of 600 nesting pairs, it is possible that the total number of nesting birds has decreased, but additional studies would be required to verify this.

104. Several additional colonial nesting species were seen resting or flying near the island, including Bonaparte's (Larus philadelphia) and ring-billed gulls (Larus delawarensis), double-crested cormorants (Phalacrocorax auritus), and Caspian terns (Sterna caspia). These species were seen primarily in sheltered areas around the eastern tip of the island, near the groin on the south shore, and in the bay at the west end near the gull-nesting area. The ring-billed gulls, cormorants, and terns are known to nest approximately 200 miles upstream in the

Columbia River (Tabor 1976). Caspian terns were also found nesting in Willapa Bay, approximately 80 km to the north. Nesting Bonaparte's gulls have not been reported in this area.

105. Preliminary investigations disclosed no recent history of dredged material deposition on East Sand Island. However, the sandy soil composition and vegetation at the eastern end of the island was similar to other areas observed in the Columbia which have received dredged material. Also, a dune which could have been a dike extended eastward along the south beach and curved northward to enclose the sandy area just described. The U.S. Army Engineers, Portland District, plans to dredge the Chinook Channel (Figure 11) and deposit these materials by pipeline on the western end of the island and near the foot of the easternmost groin on the south shore. As shown in Figure 12, the latter disposal area is adjacent to the eastern extension of the gull nesting grounds and human activity here could directly affect breeding and nesting activities. Dredged material disposal on the west tip of the island probably would not directly disturb nesting gulls. However, the extensive tidal flats in the area appeared to be an important loafing area for the nesting species and other transient birds observed. Therefore, the forced short-term relocation of these species to other feeding and loafing areas is expected. It is possible that this relocation could extend the time adult birds are absent from the nests and thus affect hatching and fledging success.

Willapa Bay, Pine Island

Physical characteristics

106. Pine Island is 5 km north of the town of Bay Center (Figure 15). In 1977 it consisted of less than 1 ha of dry sand above the high tide line and supported no vegetation. The origin of this island was presumed to be natural, although nearby North and South Snag Islands may be composed of dredged material from a privately maintained channel just east of Pine Island. The northern portion of Willapa Bay is a particularly dynamic system since it is exposed to winds, tides, and currents

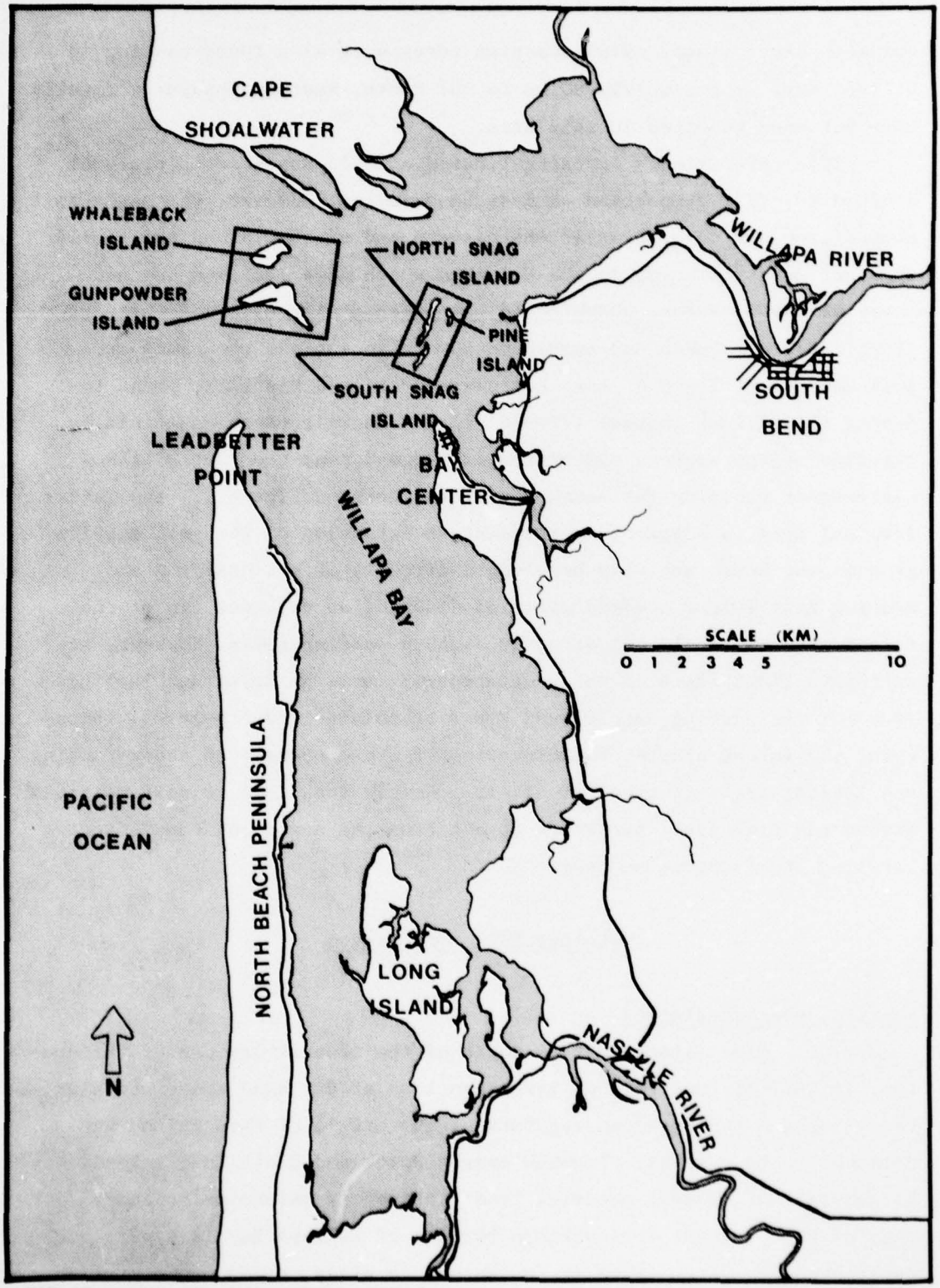


FIG. 15 WILLAPA BAY STUDY AREAS

of the Pacific. It is believed that the island was recently formed and is undergoing rapid and continuous change.

Habitat description

107. Pine Island was essentially an elongated sand shoal a few meters above high water (Figure 16). Storm tides which submerge the entire island, salt spray, and shifting sands have precluded the establishment of any permanent vegetation. The only existing habitat types were intertidal beach which graduated into an unvegetated storm tide plain. The boundaries of these areas are believed to change rapidly from season to season and year to year.

Colonial nesting species

108. The history of colonial nesting seabird use of Pine Island is uncertain, largely because of geographical ambiguities. Caspian terns have been observed at Willapa Bay at least since the 1950's, and perhaps during the late 1940's (Alcorn 1958). On what may have been Pine Island, Caspian terns, glaucous-winged/western gulls, and ring-billed gulls were observed nesting in 1976 (personal communication, 1976, Stephen Jefferies, biology student, University of Puget Sound, Tacoma, Washington). On 30 June 1977, 98 pairs of glaucous-winged/western gulls were observed nesting there, but no Caspian tern or ring-billed gull nests were found.

109. As the nucleus of their colony, the glaucous-winged/western gulls used approximately 10 large driftwood logs (Figure 16). Eighty percent of the nests were concentrated on 0.2 ha of the exposed sand. The absence of growing vegetation on the island resulted in gulls using dry, wind-thrown eelgrass for nesting material. Eelgrass nests were flimsy and superficial, and were clearly more exposed to the elements than nests in other gull colonies examined. Nesting pairs were greatly alarmed by colony disturbance and intraspecific antagonism was noticeably greater than on other islands studied. Three cases of egg predation were observed. Only eight chicks were counted among the 98 nests; the rest contained eggs. While it was not possible to monitor nesting success, productivity was probably low when compared with other colonies studied.

Vegetation at the colony

110. There was no vegetation on the island and the nesting birds used any material remaining from tides and storms that afforded protection from shifting sands. In general, this consisted of drift vegetation and beached driftwood logs.

Discussion

111. The physical and biological characteristics of Pine Island provided only a marginal nesting habitat for seabirds. Increased sedimentation could improve island stability and facilitate the establishment of permanent vegetation. This would further increase stability and provide nesting material and cover for breeding birds.

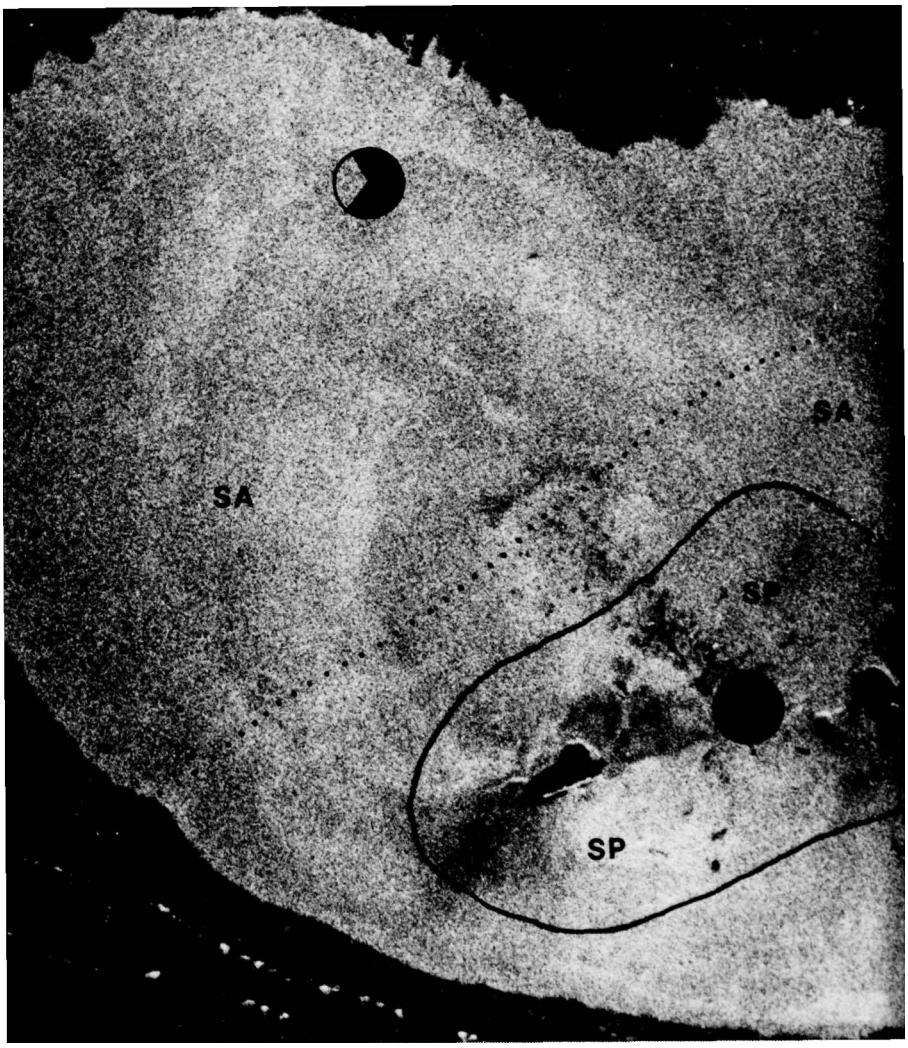
112. Because of exposure to waves and tides, the island undergoes periodic inundation. Gulls and terns are vulnerable to these physical forces, especially during the nesting season, and species composition and productivity of this island are expected to vary significantly from year to year.

113. By 30 June, hatching was well underway in other colonies studied. The fact that only eight chicks were observed in 98 nests on Pine Island at this time shows that the nesting schedule on this island was considerably later. This may have been an effect of the lack of vegetation and general exposure to physical extremes.

Willapa Bay, Gunpowder Island

Physical characteristics

114. Gunpowder Island, located at the mouth of Willapa Bay (Figure 15) near Whaleback Island, consisted of about 27 ha of sand and exhibited little relief. The west end of the island was wide and the island narrowed toward the east end, which was in effect a narrow peninsula. Gunpowder Island is the product of natural patterns of sand deposition resulting from tidal patterns and the action of waves generated during winter storms.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Habitat description

115. Habitats found on this island included a beach, grass-herb, and a storm tide plain (Figure 17). The beach provided a significant intertidal feeding zone, whereas the grass-herb and upland storm plain provided nesting sites for breeding gulls. Terns nested on a sand spit extending from the northwest of the island. Table A4, Appendix A, describes the relative densities of plant species within each habitat type.

Colonial nesting species

116. Colonies were first observed during aerial reconnaissance on 30 June, but foul weather prevented field observation until 21 July. At this time, nesting colonies of Caspian terns and glaucous-winged/western gulls were found. The tern colony was located on the narrow spit extending southeast from the island (Figure 18) and consisted of approximately 100 nesting pairs. Nests were not counted since colony disturbance was expected to result in significant mortalities. Twenty chicks were observed in addition to fifteen recently fledged young. It was estimated that approximately 75 young were successfully fledged from 30 nests.

117. Approximately 1000 glaucous-winged/western gull nests were observed on the main body of the island. Nests were counted from one point within the colony and the number compared with counts of adults near the colony. No eggs were found; all chicks were approximately half grown and not fully fledged. Three tern nests containing eggs were found near the edge of the gull colony.

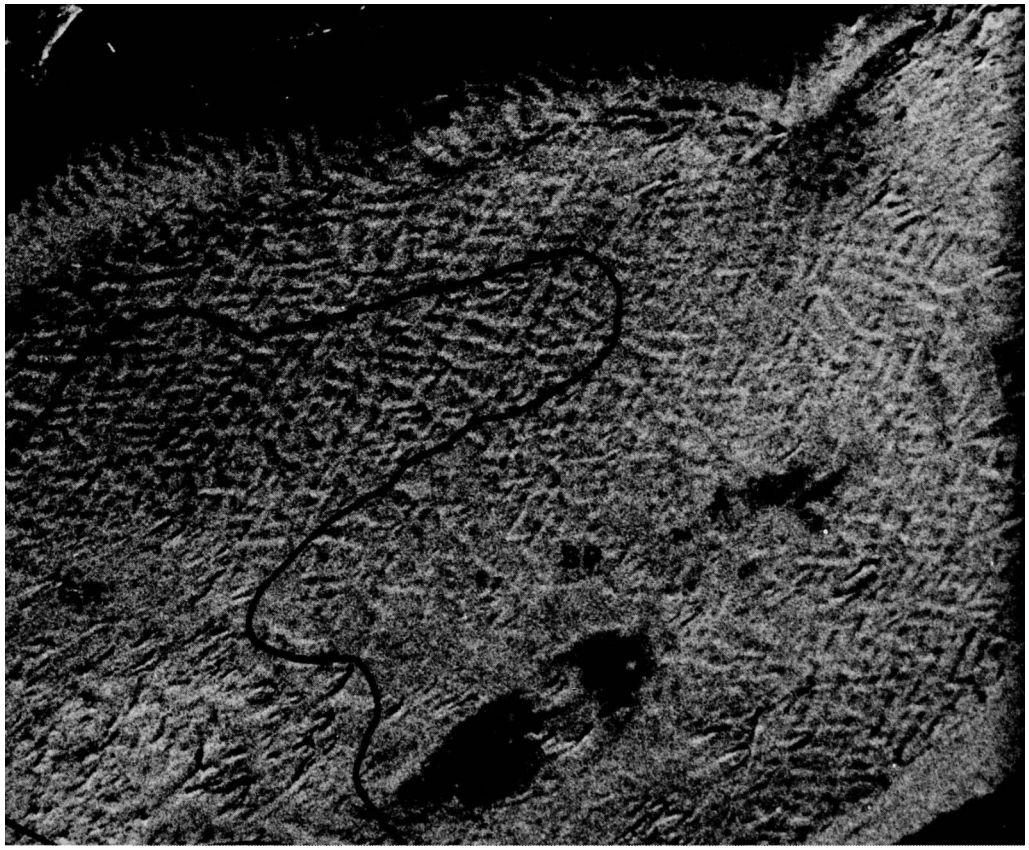
Vegetation at the colony

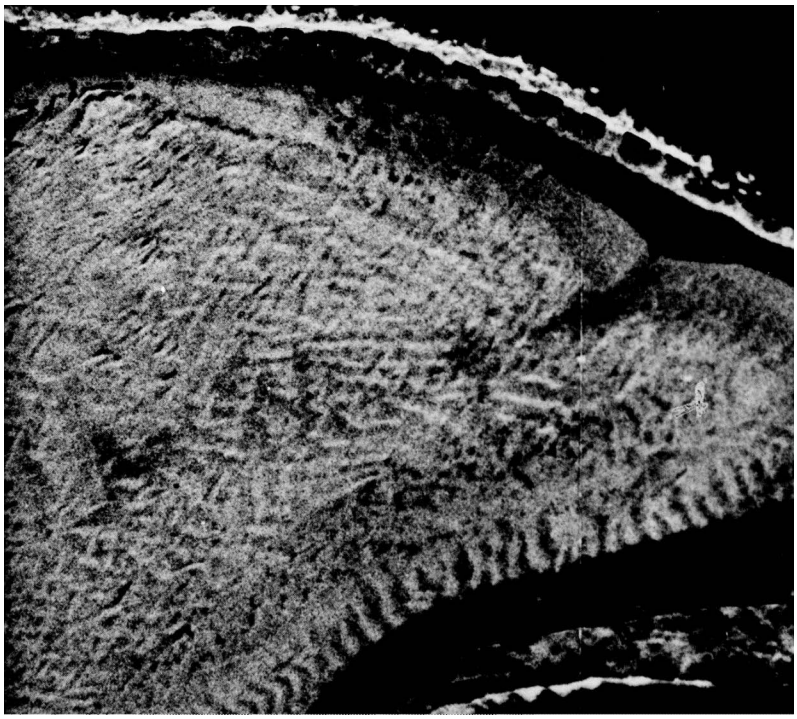
118. Two vegetation transects, one in each of the two primary gull nesting areas (the tern colony was without vegetation), demonstrated that Gunpowder Island supported only four species of plants (Table 16). The north colony transect, running 150 m southeast from the west end of the island across the grass-herb habitat, included all four species: American searocket, American dunegrass, European beachgrass (Ammophila arenaria), and sea purslane (Honkenya peploides). Searocket, the most

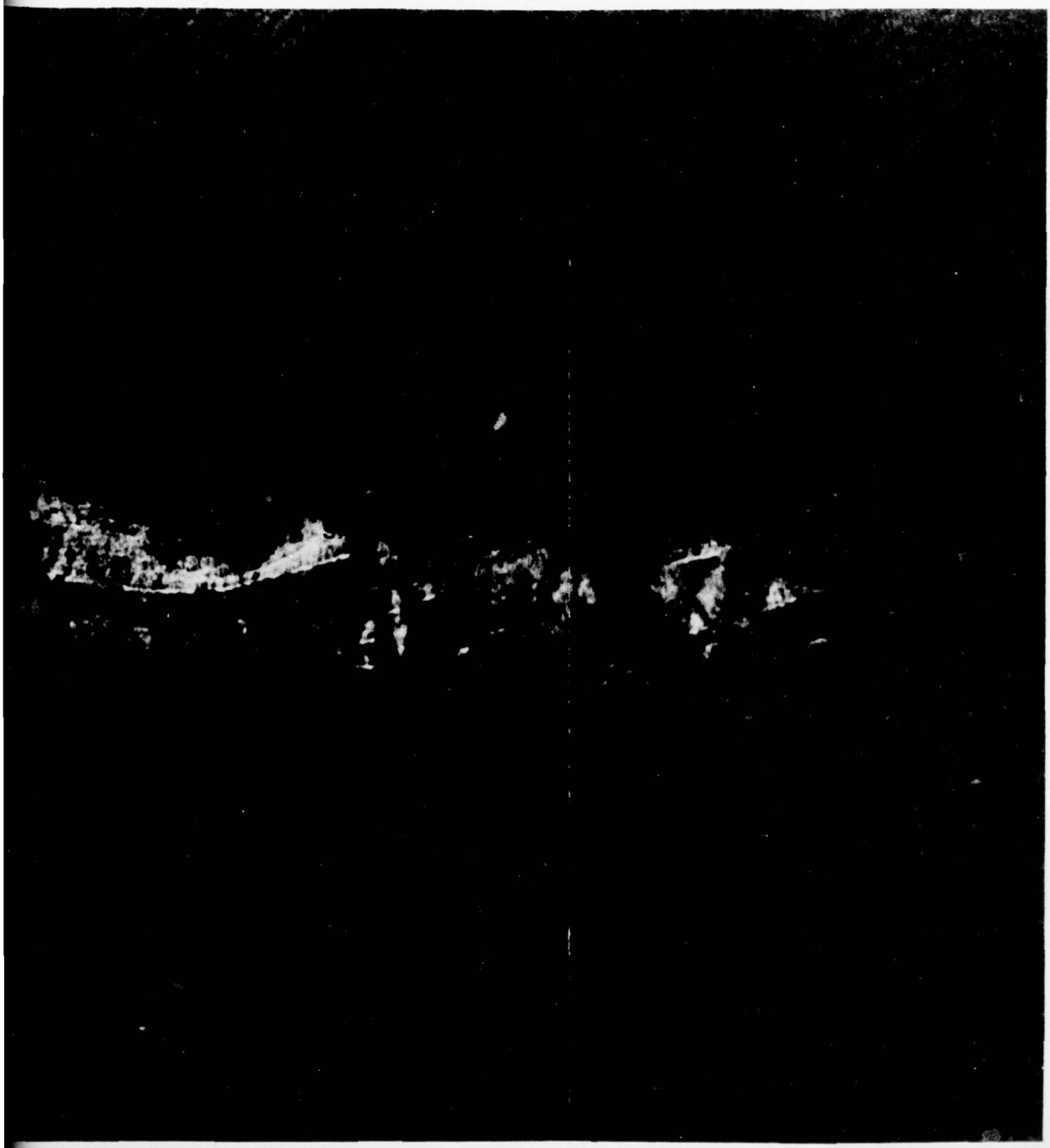
Table 16

Vegetation in the Gull Colonies of Gunpowder Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
South Colony					
Grasses	American dunegrass	137.7	1.5	0- 75	4
	European beachgrass	62.3	1.1	0- 80	1
Herbs	American searocket	161.3	4.9	0- 80	18
	Sea purslane	38.7	1.0	0- 40	5
North Colony					
Grasses	American dunegrass	189.8	7.0	0- 50	31
	European beachgrass	10.2	0.3	0- 15	2







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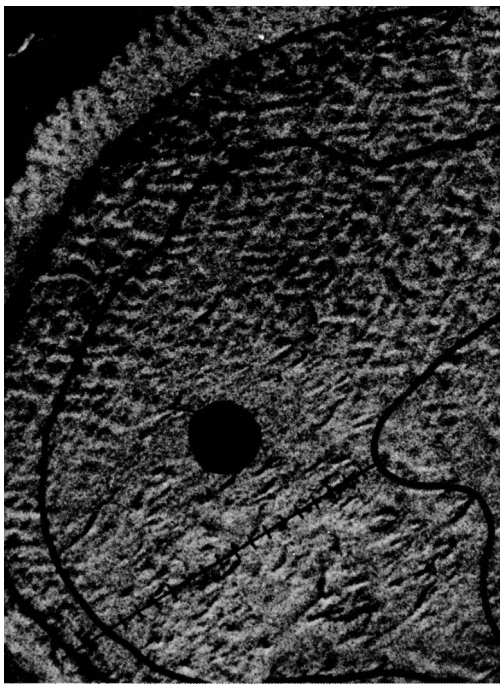

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COLONIAL NESTING SEA AND WADING BIRD USE OF ESTUARINE ISLANDS I--ETC(U)
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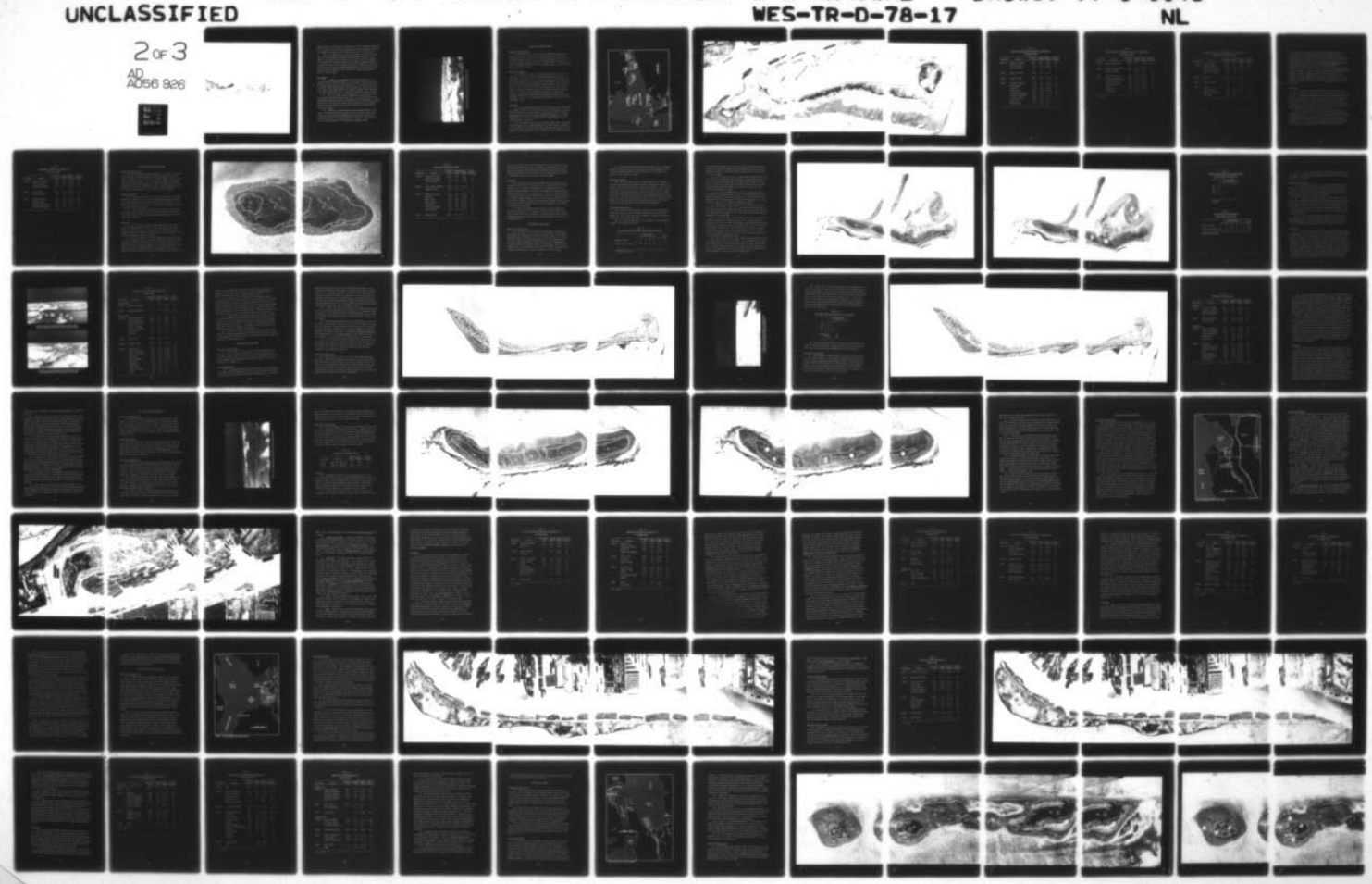

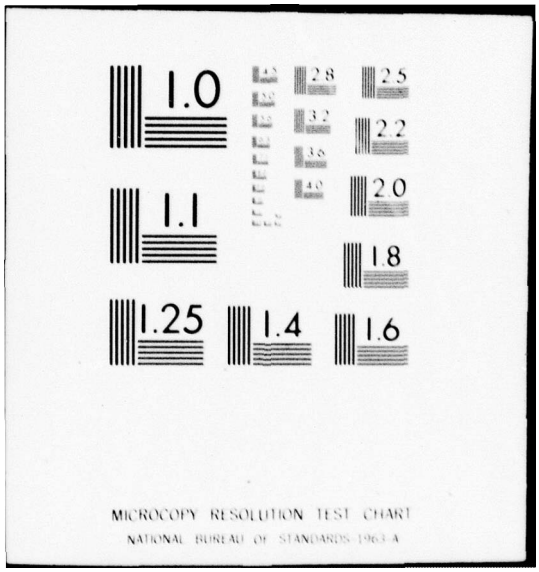
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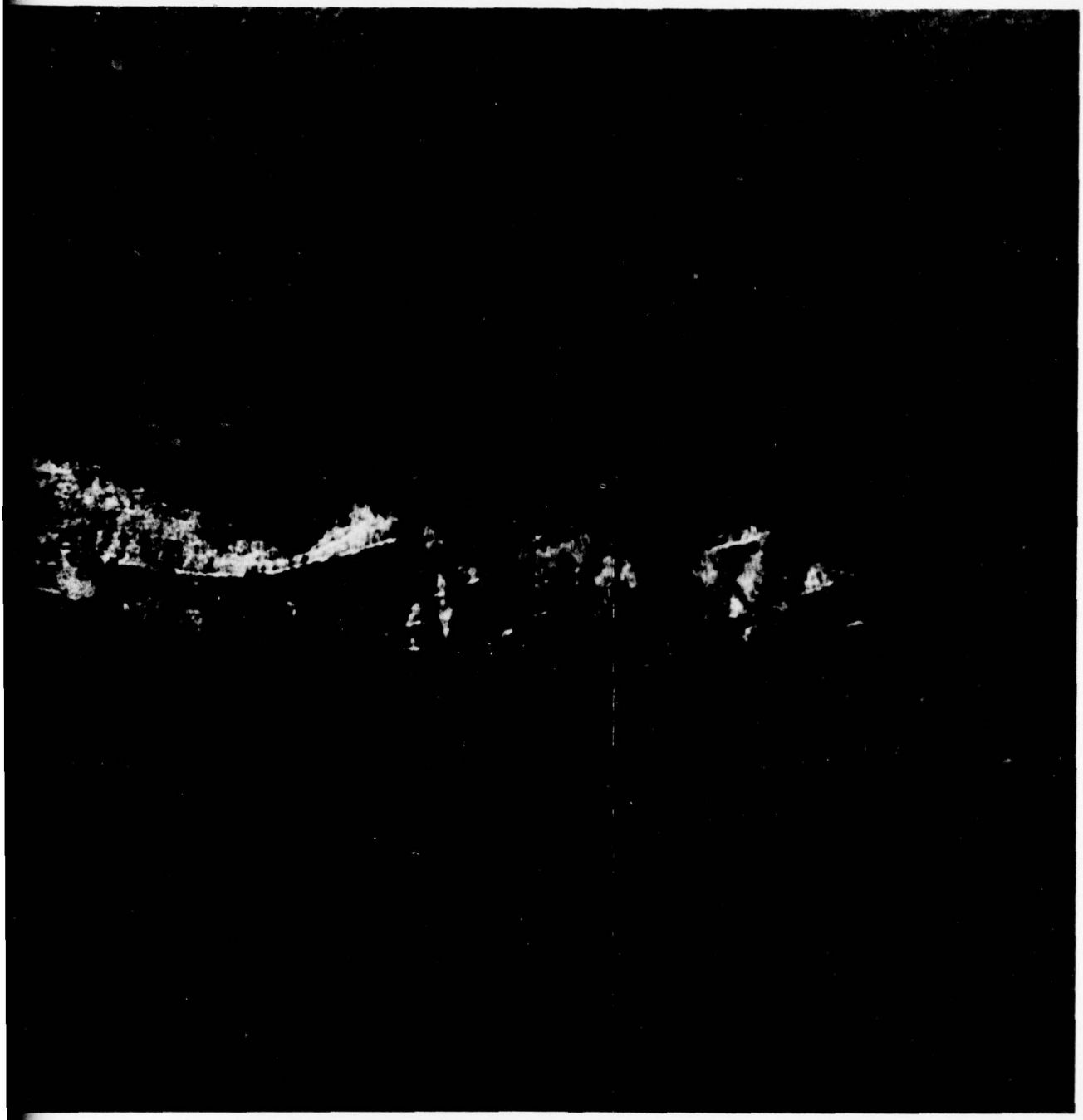

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common species, was found in 18.4 percent of the test plots and accounted for 4.9 percent cover. European beachgrass was least frequently found in the transect (1.3 percent) and accounted for only 1.1 percent cover.

119. The second transect, 100 m long across the storm tide plain, passed almost exclusively through American dunegrass (Figure 19 and Table 16). This species occurred in 31.4 percent of the test quadrats and accounted for 7 percent of the cover. European beachgrass played an ecologically minor role in island stabilization, exhibiting less than 5 percent cover and 5 percent frequency. Apparently, the distribution and concentration of vegetation were adequate for large concentrations of gulls to produce young.

Discussion

120. Gunpowder Island appeared to be the most dynamic of the islands observed, probably because of its proximity to the open ocean. The primary gull colony near the west end of the island was protected by a sparsely vegetated dune system. The secondary gull nesting site was also within a vegetated region. The colonies appeared fairly successful during the single visit and it is believed that productivity was high.

121. The tern colony, on the unvegetated spit, appeared to be maintaining a tenuous existence very close to the summer high tide line. Unseasonably high tides may have inundated this site and affected nesting productivity. The three tern nests near the gull colony were probably renesting efforts and may have been from pairs which unsuccessfully nested on the spit.

122. Should the island stabilize and become more densely vegetated, increased gull nesting habitat would be provided. Terns would probably continue to select unvegetated beach and spit habitat, but would choose other more sparsely vegetated islands as colony sites if these preferred areas are not available on Gunpowder Island.

FIGURE 19. GULL NESTING HABITAT OF GUNPOWDER ISLAND, VIEW TO THE NORTH FROM THE WEST END OF THE ISLAND

Grays Harbor, Rennie Island

Physical characteristics

123. Rennie Island is in the terminal navigation channel of the Chehalis River south of the city of Hoquiam (Figure 20). On a 1913 topographical map, it appeared as a broad oval island, whereas in 1977 it was elongated, largely as a result of dredged material deposition. A large, rectangular settling pond for paper mill wastes is located within the center of the island.

Habitat description

124. Habitats of Rennie Island are identified in Figure 21. The east end of the island recently had dredged material deposited on it, and therefore vegetation was at a very early seral stage. Elsewhere on the island, vegetation was quite diverse, with high and low salt marsh habitats surrounding the island and a small freshwater marsh located at the west end. The freshwater marsh was surrounded by a well-developed stand of red alder. A mudflat around the island was generally unvegetated, but in some areas supported low densities of brass button (Cotula coronopifolia) and glasswort (Salicornia virginica). Table A5, Appendix A, lists the species and relative density of vegetation within each habitat type.

Vegetation

125. Four vegetation transects were examined on Rennie Island and are shown in Figure 21. The lower salt marsh was submerged at high tide and was dominated by Lyngby's sedge or three-square bulrush (Scirpus americanus) and seaside arrowgrass (Triglochin maritima). The single vegetation layer of the low marsh had cover ranging from 80 to 100 percent (Tables 17 and 18).

126. As shown in Table 19, the high salt marsh had as codominants tufted hairgrass and creeping bentgrass, with both species covering 80 to 100 percent of the sample plots. The high marsh was inundated only at mhhw. Part of the south side of the island was covered with a wide belt

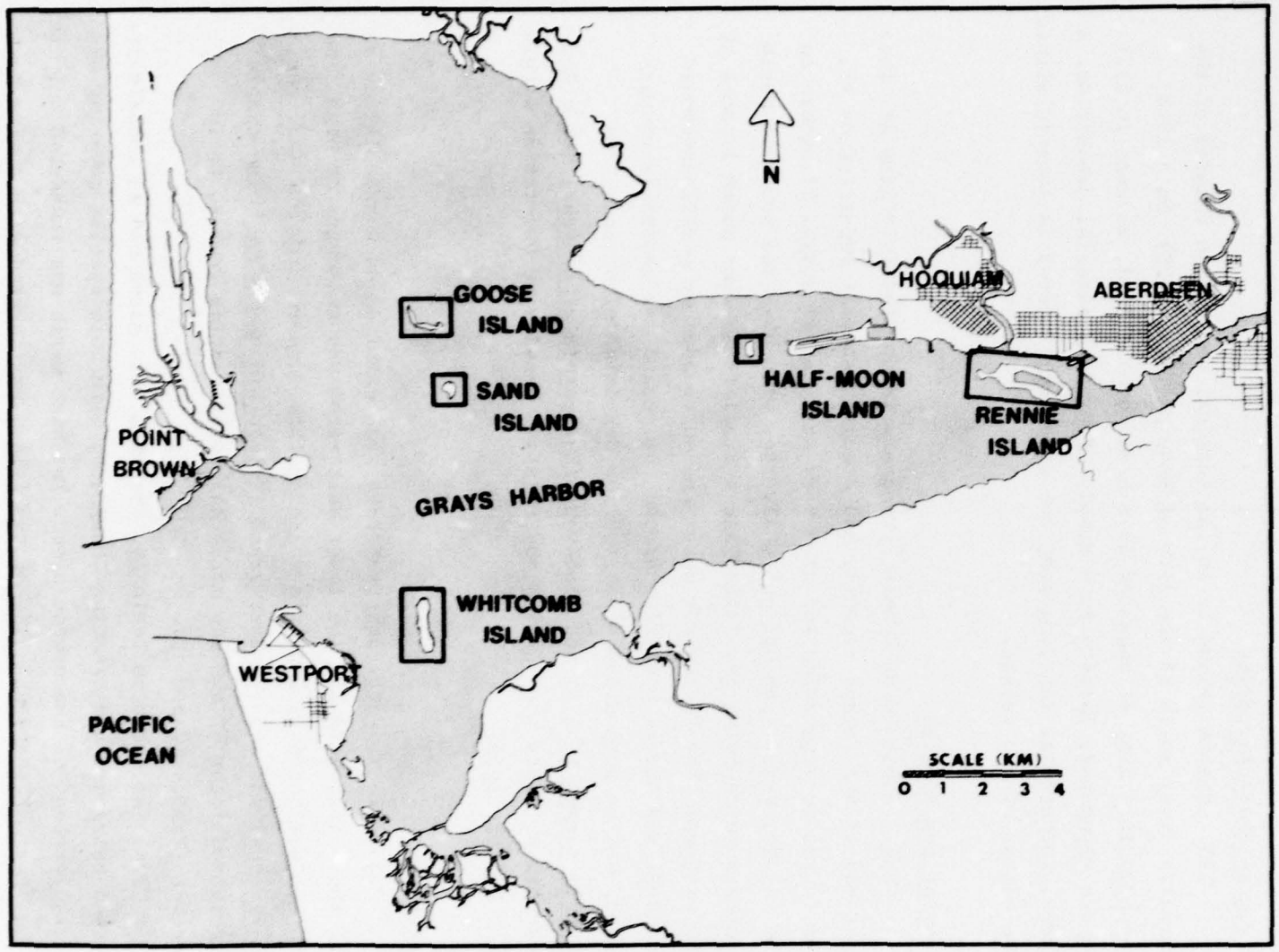

FIG.20 GRAYS HARBOR STUDY AREAS


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Table 17

Marsh and Dike Habitat (Transect 1) Vegetation of Rennie Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grasses	Creeping bentgrass	139.4	19.3	0- 95	37
	Tufted hairgrass	54.5	6.4	0-100	17
	Reed canarygrass	6.1	0.3	0- 10	3
Rushes	Common horsetail	200.0	0.1	0- 5	3
Sedges	Lyngby's sedge	200.0	23.9	0-100	40
Herbs	Seaside arrowgrass	54.8	2.4	0- 30	23
	Brass buttons	53.6	2.3	0- 20	23
	Birdsfoot	17.8	0.9	0- 25	6
	Shore orache	23.2	0.9	0- 10	11
	Old-man-in-the-spring	15.2	0.7	0- 20	6
	Pacific silverweed	10.3	0.3	0- 5	6
	Canadian thistle	10.3	0.3	0- 5	6
	Curly dock	10.3	0.3	0- 5	6
	Common thistle	4.5	0.1	0- 5	3

Table 18

Beach and Low Marsh Habitat (Transect 2) Vegetation of Rennie Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	American dunegrass	200.0	11.1	0- 80	50
Sedges	Three-square bulrush	183.1	16.1	0- 90	27
	Lyngby's sedge	16.9	0.2	0-T	5
Herbs	American searocket	103.9	6.4	0- 60	27
	Old-man-in-the-spring	16.3	0.9	0- 20	5
	Brass buttons	14.3	0.7	0- 15	5
	Seaside arrowgrass	27.1	0.7	0-T	14
	Yarrow	20.0	0.7	0- 10	9
	Pickleweed	9.2	0.2	0- 5	5
	Giant vetch	9.2	0.2	0- 5	5

* T: Trace

Table 19

Mudflat, Low Marsh, and Dike Habitat (Transect 3)

Vegetation of Rennie Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grasses	Tufted hairgrass	130.7	32.2	0-100	58
	Creeping bentgrass	48.0	6.9	0-100	33
	Common velvetgrass	12.3	2.8	0- 70	6
	Rabbitfoot polypogon	9.0	1.4	0- 45	6
Rushes	Baltic rush	200.0	1.4	0- 40	6
Sedges	Lyngby's sedge	200.0	5.1	0- 95	33
Herbs	Cattail	73.4	2.4	0- 80	6
	Brass buttons	92.1	1.1	0- 10	17
	Seaside arrowgrass	31.1	0.4	0- 5	8
	Pickleweed	23.4	0.3	0- 5	6

of driftwood, which excluded vegetation. Behind the driftwood was a protected zone, with tufted hairgrass, some stunted red alder, and assorted herbaceous vegetation. A borrow pit accumulated freshwater and was flooded at high tides; the water was usually brackish. Baltic rush (Juncus balticus), rabbitfoot polypogon (Polypogon monspeliensis), and characteristic species. The dike was a disturbed habitat characterized by two to three layers of herb and shrub vegetation (Table 20) made up largely of exotics such as Canadian thistle (Cirsium arvense), evergreen blackberry (Rubus laciniatus), Himalayan blackberry (R. discolor), and also common horsetail (Equisetum arvense). This area included some dredged material. A small dune system existed at the west end of the island with some Hooker willow (Salix hookeriana) growing on the sandy area.

Discussion

127. Although colonial seabirds did not nest on Rennie Island, the island is important as a nesting and visitation site for a wide variety of shorebirds and passerines. Migrating and wintering shorebirds rest, roost, and feed in various habitats of the island, including the paper mill waste settling pond and the extensive mudflat along the perimeter of the island. Nonmarine waterfowl feed and rest in the pond, and the shallow exposed marshy area just west of the main island receives especially high use by wading birds, gulls, and terns.

128. The island is not likely to be used as a nesting site for waterbirds in the near future because of the advanced successional stage of vegetation; absence of beach, dune, and grass habitat types; and its susceptibility to human disturbance. Extension of the low and upland marsh areas by the deposition of dredged materials on the western end of the island would increase habitat for migrant and wintering birds.

Table 20

Dike Habitat (Transect 4) Vegetation of Rennie Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grasses	Common velvetgrass	124.5	45.6	0- 90	63
	Reed canarygrass	63.2	14.4	0- 80	50
	Creeping bentgrass	12.3	1.2	0- 10	13
Rushes	Baltic rush	121.1	12.5	0-100	13
	Common horsetail	78.9	1.9	0- 10	25
Herbs	Canadian thistle	83.1	3.8	0- 20	38
	Common thistle	54.7	2.5	0- 15	25
	Old-man-in-the-spring	34.8	1.9	0- 15	13
	Himalayan blackberry	27.4	1.2	0- 10	13

Grays Harbor, Half Moon Island

Physical characteristics

129. Half Moon Island, shown in Figure 20, lies just to the west of Moon Island, a peninsula composed of dredged material that is the site of Bowerman Field, an airport. Half Moon is roughly circular, and at high tide covers about 7 ha. It is composed primarily of dredged sand deposited from 1973 through 1975. The low island exhibits little topographic relief and is virtually contiguous with the mainland at low tide. The intervening mudflat is not easily traversed, however.

Habitat description

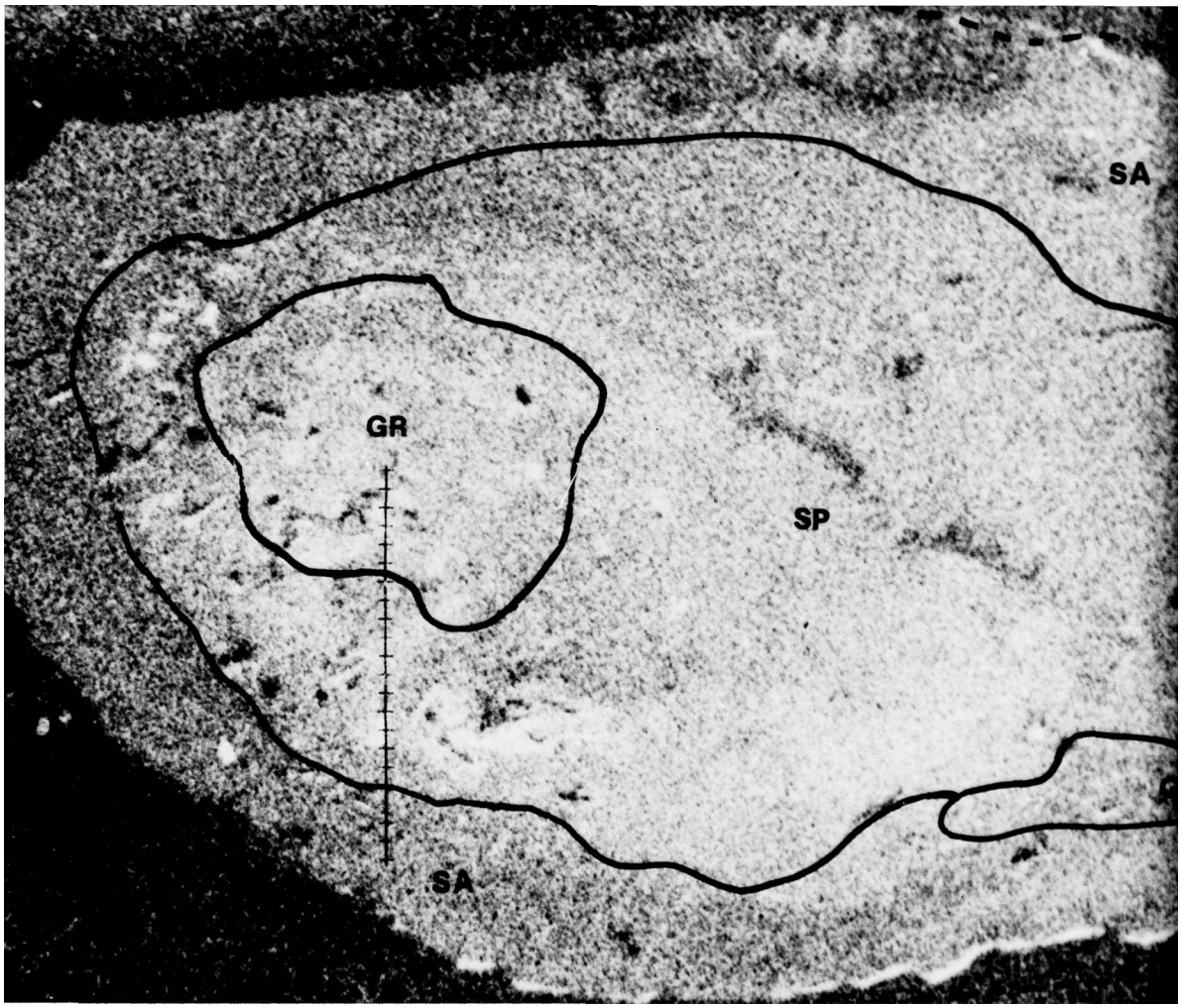
130. The most conspicuous feature of the island was the abundant driftwood covering much of it, which suggested that the entire island was a large storm tide plain. Figure 22 delineates the extent of this habitat and shows the location of two small grass-herb habitat types and an extensive intertidal sand flat.

131. Many diverse types of plants were observed on this physiographically simple island (Table A6, Appendix A). Many of the species were found in both storm tide plain and grass-herb habitat, but occurred at different densities.

Vegetation

132. The vegetation transect through grass-herb, storm tide plain, and sand flat habitats best described the plant characteristics across the island (Table 21). The diversity was probably due to the island's considerable distance from the open sea, which excluded it from periodic destructive inundation by waves.

133. Creeping bentgrass, although common in the storm tide plain (32 percent frequency, 10 percent cover), exhibited the greatest concentrations within the interior upland. Here it accounted for up to 80 percent of the cover and was observed in 87 percent of the sample plots. American searocket, although observed over a greater portion of the total transect (34 percent of the plots), accounted for an average cover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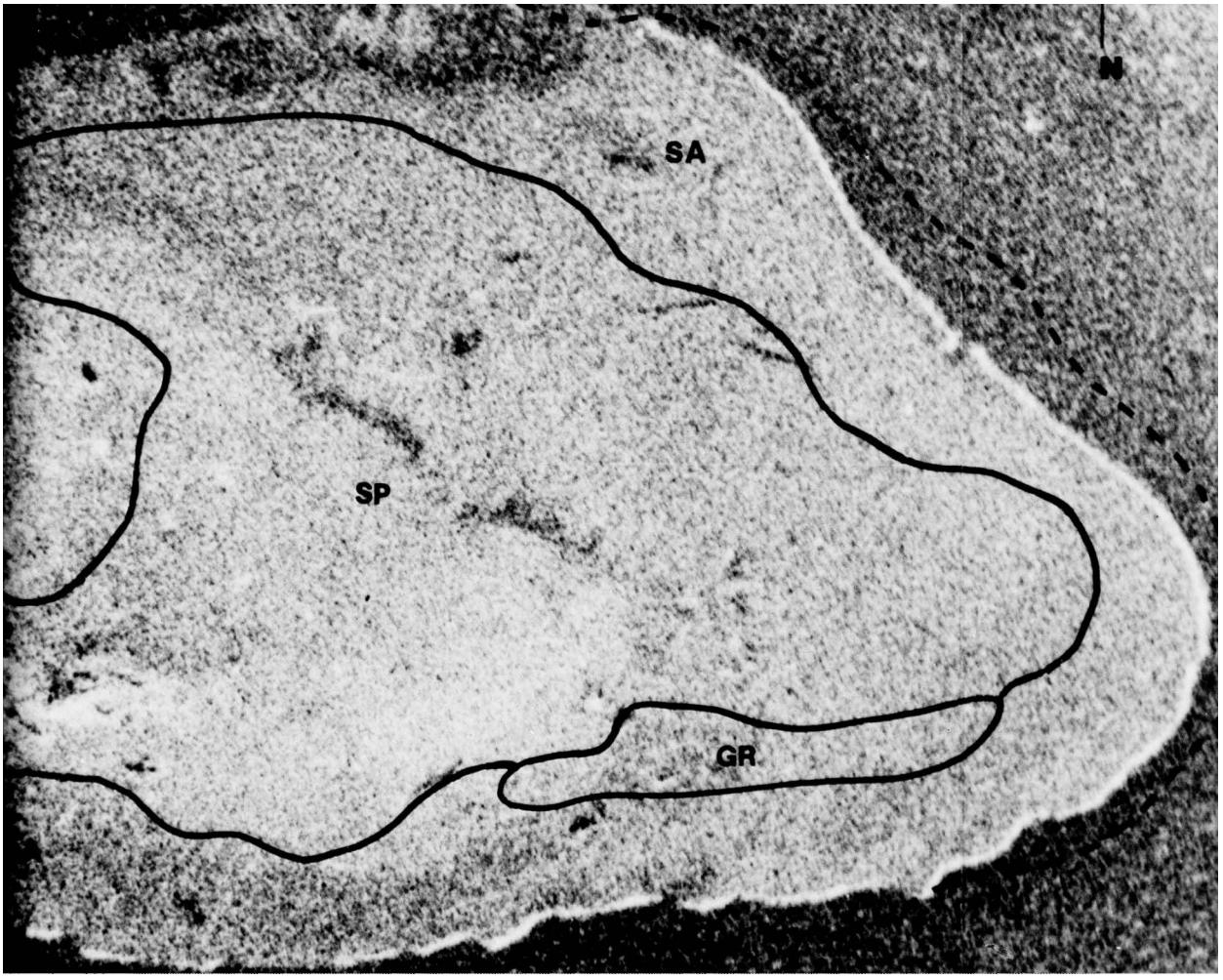
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Table 21

Vegetation of Half Moon Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grasses	Creeping bentgrass	128.3	10.0	0- 80	32
	American dunegrass	57.5	2.4	0- 30	24
	Tufted hairgrass	14.2	0.8	0- 15	5
Sedges	Three-square bulrush	145.8	0.5	0- 10	5
	Lyngby's sedge	54.2	0.1	0- 5	3
Herbs	American searocket	104.1	6.6	0- 45	34
	Beach pea	25.9	1.7	0- 30	8
	Shore orache	17.6	0.8	0- 10	8
	Sheep sorrel	14.7	0.5	0- 10	8
	Yellow dock	14.7	0.5	0- 10	8
	Pacific silverweed	13.8	0.4	0- 5	8
	Brass buttons	9.2	0.3	0- 5	5
Trees	Hooker willow	200.0	0.3	0- 5	5

of only 6.6 percent. Its primary distribution occurred within the storm tide plain and sand flat. American dunegrass, the third most prevalent species, occurred as scattered clumps throughout grass-herb and storm tide plain habitats. Its sparse cover was low when compared with the 80 to 100 percent cover for this species on other islands.

Discussion

134. Half Moon Island did not support nesting colonies of gulls or terns in 1977, but it is conceivable that it may in the future. The location, size, and unique distribution of creeping bentgrass, sea-rocket, American dunegrass, and other less numerically important grasses and herbs indicated that this island had the essential characteristics for successful gull and tern colonization. However, its location adjacent to a primary shipping channel, and its relatively great distance from the sea, may combine to counter these advantages and make it unattractive as a nesting site for these seabird species, especially if other habitable islands are available.

135. Half Moon Island has been primarily used by feeding and roosting shorebirds and, to a lesser extent, by loafing gulls, terns, and some waterfowl. Tens of thousands of migrating and wintering shorebirds have used this island and the nearby flats north of the west end of Bowerman Field.

Grays Harbor, Sand Island

Physical characteristics

136. As shown in Figure 20, Sand Island, about 8 km due west of Half Moon, lies nearly in the center of the north bay of Grays Harbor. This island and its neighbor to the north, Goose Island, are of recent geologic origin, neither island appearing on a 1913 topographic map of the region. Both were probably created from increased sedimentation resulting from the construction early in this century of the north and south jetties at the entrance to the harbor. The shape of Sand Island is constantly changing, but is altered primarily by winter storms.

137. The island is oriented primarily east/west, with a northern extension at the west end and a narrow east/west bar running east from the north extension parallel with the main body of the island. The majority of the substrate is sand.

Habitat description

138. The distribution of Sand Island habitat types is shown in Figure 23 and vegetation abundance is listed in Appendix A, Table A7. A discrete and well-developed area of vegetation bounded by a dune on the west made up the east end of Sand Island. The central area was covered with grasses and herbs and some driftwood. The terrain of the northern part of the island consisted of gently rolling hummocks sparsely covered by grasses. It is here that many gulls rested, and the vegetation at the height of the nesting season was compressed by the gulls. This entire area was used for nesting by western/glaucous-winged gulls.

Colonial nesting species

139. In 1977 an estimated 800 to 1000 pairs of western/glaucous-winged gulls and 1700 pairs of Caspian terns nested on Sand Island (Figure 24). Five visits were made throughout the season to determine population size and nesting status.

140. On 22 May, 66 gull nests were observed in a representative portion of the colony (Table 22).

Table 22

Nest Status of Gull Colony, Sand Island, 22 May 1977

	Clutch Size				Total
	0	1	2	3	
Number of Nests	11	9	19	27	66
Percent Active Nests	20*	16	34	49	--

* Percent total nests

Assuming that 10 percent (6) of the active nests consisted of two-egg clutches, it appeared that egg-laying was complete in 33 nests or 60 percent of the total. Laying had probably been initiated in all active nests by this time.

141. Of the 66 nests, 18 nests representing a similar clutch size distribution were marked and observed during a subsequent visit on 14 June. By this time, nesting status had progressed as shown in Table 23. Only one two-egg clutch remained; the others and all previous one-egg clutches contained an additional egg. Eight (47 percent) of the 17 active nests had begun to hatch.

142. By 14 July, 1 month later, only 4 (23 percent) of the 17 active nests still contained chicks, and 1 nest of three eggs had not hatched. Twelve nests could not be located. All chicks observed on the island were more than half-grown, but none had fledged. However, by the time of the next visit, 17 August, fledging was complete.

143. Egg-laying was well underway in the Caspian tern colony by the first visit on 22 May (Table 24). Eight eggs were pipped and one chick had just hatched near the edge of the colony. These data indicated that approximately two thirds of the colony had completed egg-laying and hatching was just beginning.

144. Of the 229 nests, 30 were individually marked and observed during the next visit on 26 May. At this time, a team of observers counted 1737 tern nests on the island; many of the young had hatched and the huge mobile groups of chicks precluded any precise counts. Of the 30 nests marked 4 days earlier, 3 had at least one less egg, 2 contained a recently hatched chick, and 1 nest had disappeared. Thus, at least 7 percent and perhaps as many as 17 percent of the nests had begun hatching. No additional eggs had been laid.

145. Three weeks later (14 June), almost all eggs had hatched and the chicks had left the nest. On 14 July, 13 nests (most with two eggs) were located west of the primary nesting area. A representative sample of tern chicks was also observed. Of 121 young, 90 were categorized as large, 15 were medium, and 6 were still downy. Eleven dead chicks were found throughout the colony and one had been banded.

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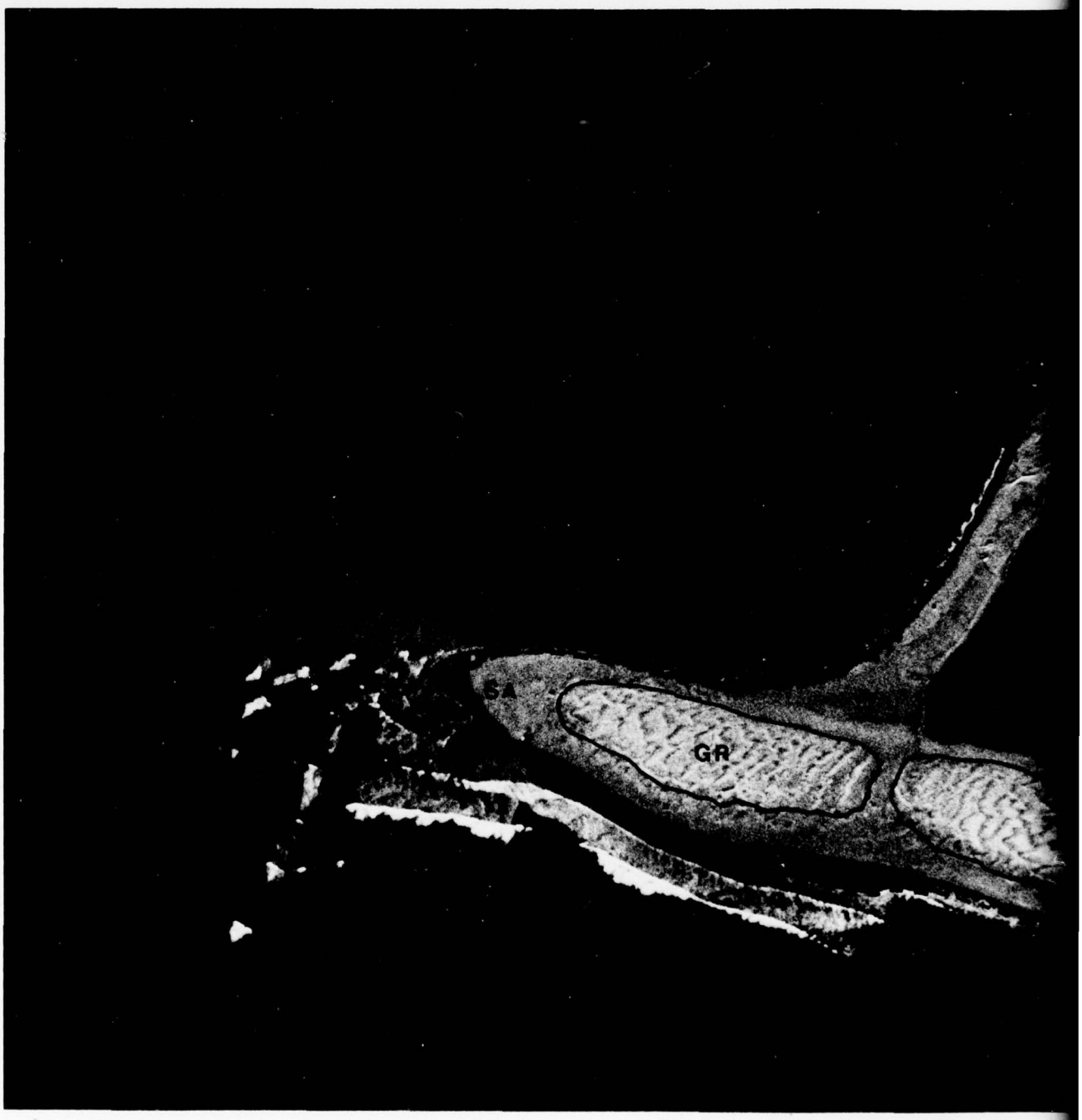

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Table 23

Status of Marked Nests in the Gull Colony on Sand Island, 14 June 1977

		n Chicks/Nest			
		0	1	2	3
n Eggs/Nest	0	1		2	1
	1				
	2	1	5*		
	3	7			

* Pipping

Table 24

Nest Status of Tern Colony on Sand Island, 22 May 1977

	Clutch Size					Total
	0	1	2	3	4	
Number of Nests	1	6	67	150	5	229
Percent Active Nests *	4	3	29	66	2	100

*Percent total nests

146. By 17 August, approximately 120 flightless young remained in the colony. Six nests containing eggs were also found and 50 dead young (5 banded) were observed.

Vegetation at the colony

147. Terns nested throughout the sparsely vegetated storm tide plain, but were most numerous within the grass-herb habitat toward the southwest end of the island (Figure 25). Gulls, on the other hand, nested on the higher elevation dune and grass-herb habitats available at the northeast section of the island (Figure 26).

148. The vegetation transect through the Sand Island tern colony showed only two plant species, American dunegrass and American searocket, which were approximately equal in distribution and abundance (Table 25). Clam shells and sand occupied much of the unvegetated remainder of the colony substrate. The mix of vegetated to nonvegetated substrate at the colony suggested that the terns may have selected these characteristics for breeding areas.

149. The gull colony vegetation transect data (Table 25) show that dunegrass was the dominant plant over much of this area, with creeping bentgrass becoming very prominent well into the colony area. A number of herbaceous species were also found throughout the colony.

Discussion

150. The vegetation of Sand Island was quite stable and well protected from all but the most severe waves and weather, and thus afforded an ideal colony site. Some vegetation was required for successful gull nesting, as indicated by the presence of American dunegrass, creeping bentgrass, and other species observed in the colony. The relationship of vegetation to gull nesting and nesting success, however, is difficult to quantify. It appeared that the primary nesting areas of this island were not significantly related to vegetation, but rather to physical protection afforded by the dunes. Areas of heaviest nesting density were characterized by worn and thinned vegetation. Nests in sparse vegetation were frequently hidden among logs and drift material, and fledging

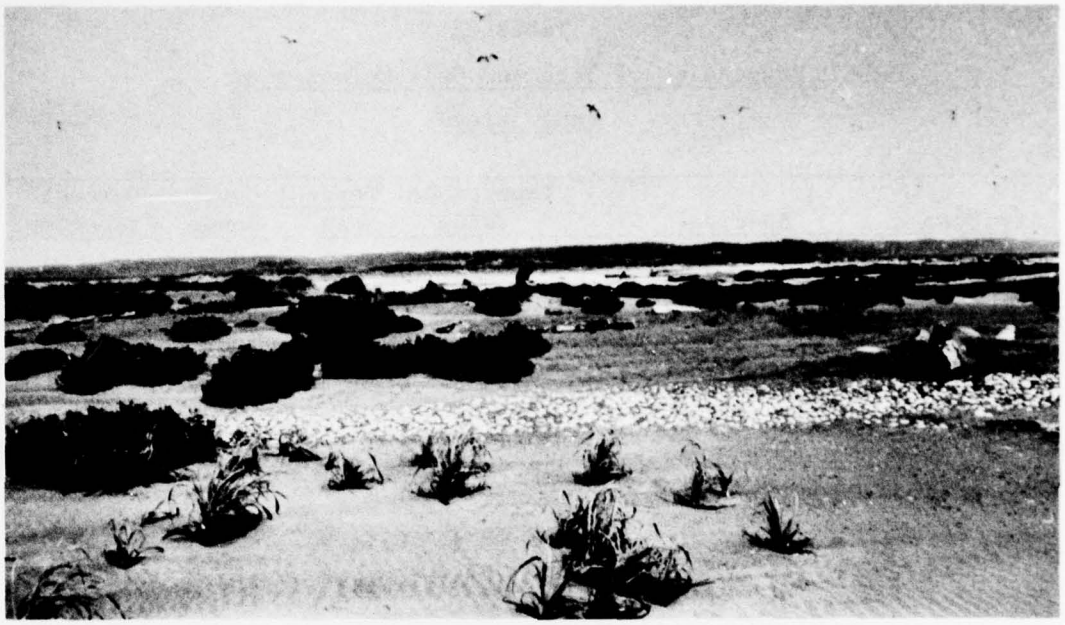


FIGURE 25. CASPIAN TERN NESTING HABITAT ON SAND ISLAND, VIEW TO THE NORTHWEST FROM THE EAST EDGE OF THE COLONY

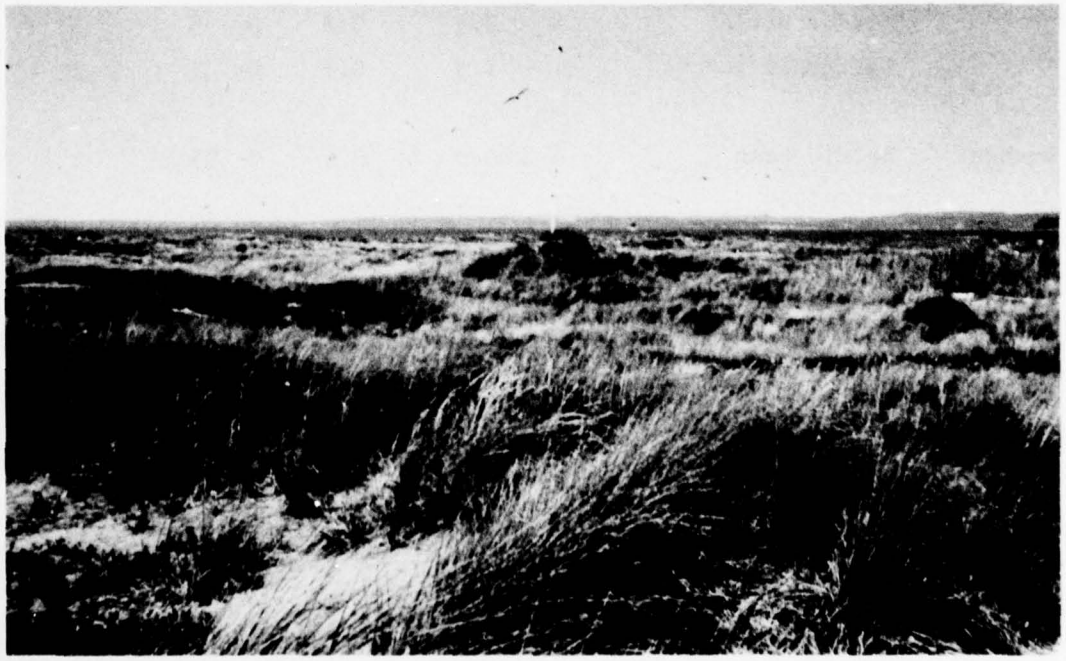


FIGURE 26. GULL NESTING HABITAT ON SAND ISLAND, VIEW TO THE NORTHEAST FROM THE SOUTH EDGE OF THE COLONY

Table 25

Vegetation of Tern and Gull Colonies of Sand Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Tern Colony					
Grasses	American dunegrass	--	7.1	0- 90	20
Herbs	American searocket	--	8.4	0- 90	16
Gull Colony					
Grasses	American dunegrass	86.3	30.7	0-100	67
	Creeping bentgrass	84.0	29.2	0-100	67
	Common velvet grass	15.3	4.2	0- 70	15
	Tufted hairgrass	5.7	1.4	0- 30	6
	European beachgrass	4.9	0.9	0- 30	6
	Meadow barley	2.1	0.2	0- 5	3
	Saltgrass	1.3	0.1	0- 5	2
Rushes	Baltic rush	200.0	0.5	0- 35	2
Sedges	Lyngby's sedge	200.0	0.4	0- 10	6
Herbs	Shore orache	102.9	8.1	0- 90	29
	American searocket	25.8	2.3	0- 80	6
	Pacific silverweed	27.5	1.9	0- 45	9
	Beach pea	17.3	0.7	0- 20	8
	Lady's-nightcap	7.5	0.4	0- 15	3
	Sea-watch	3.8	0.1	0- 5	2
	Salmonberry	3.8	0.1	0- 5	2
	Giant vetch	3.8	0.1	0- 5	2
	Common sow-thistle	3.8	0.1	0- 5	2
	Yarrow	3.8	0.1	0- 5	2

success was probably higher in these areas. During a normal growing season, it is unlikely that the grasses on this island ever reach a height or density that would preclude nesting by gulls.

151. Terns first nested on Sand Island in 1976 when Penland (1976b) reported 600 pairs. The increase to 1737 reported in this study may not indicate an increase in the total population of the area, however. Increases in the tern populations of any of the three Grays Harbor islands (Sand, Goose, and Whitcomb) have been followed by decreases on the other islands, and it is thought that many of the terns move between islands as habitat is altered (Penland 1976b, Smith and Mudd 1976).

152. In August 1973, Sand Island, owned by the State of Washington, was given "Natural Area Preserve" status and was withdrawn from sale or lease by the Washington Department of Natural Resources (DNR). Limited protection is provided by a sign on the island which prohibits entry from 1 May to 31 August. Entry permits may be obtained from the DNR Sanctuary Office in Chehalis, Washington.

153. The preserve status was originally enacted to protect the harbor seals (Phoca vitulina) which congregated on the island. However, the gull and tern colonies are also protected since the entry limitation spans their peak nesting periods.

Grays Harbor, Goose Island

Physical characteristics

154. Goose Island is located in the northern portion of Grays Harbor, as shown in Figure 20. In 1977, it was narrow and distinctly hooked at the west end, and exhibited a wide curved terminus at the east end, resulting in a protected bay along the north shore. The greatest elevation was roughly 5 m.

Habitat description

155. Goose Island exhibited sand flat, beach, storm tide plain, dune, and grass-herb habitats (Figure 27). Three of these five habitats (storm tide plain excluded) formed narrow concentric bands of distinct

vegetation around the central core of the grass-herb habitat. A wide sand flat was present on the island's protected north side, but became narrower as it extended around the east and west spits and along the south side. Upland, the sand flat graded into a distinctive beach colonized by only two plant species, American searocket and sea purslane. The beach was further characterized by abundant driftwood, especially on the south and west sides. Plant species composition and relative density within habitat types are shown in Appendix A, Table A8.

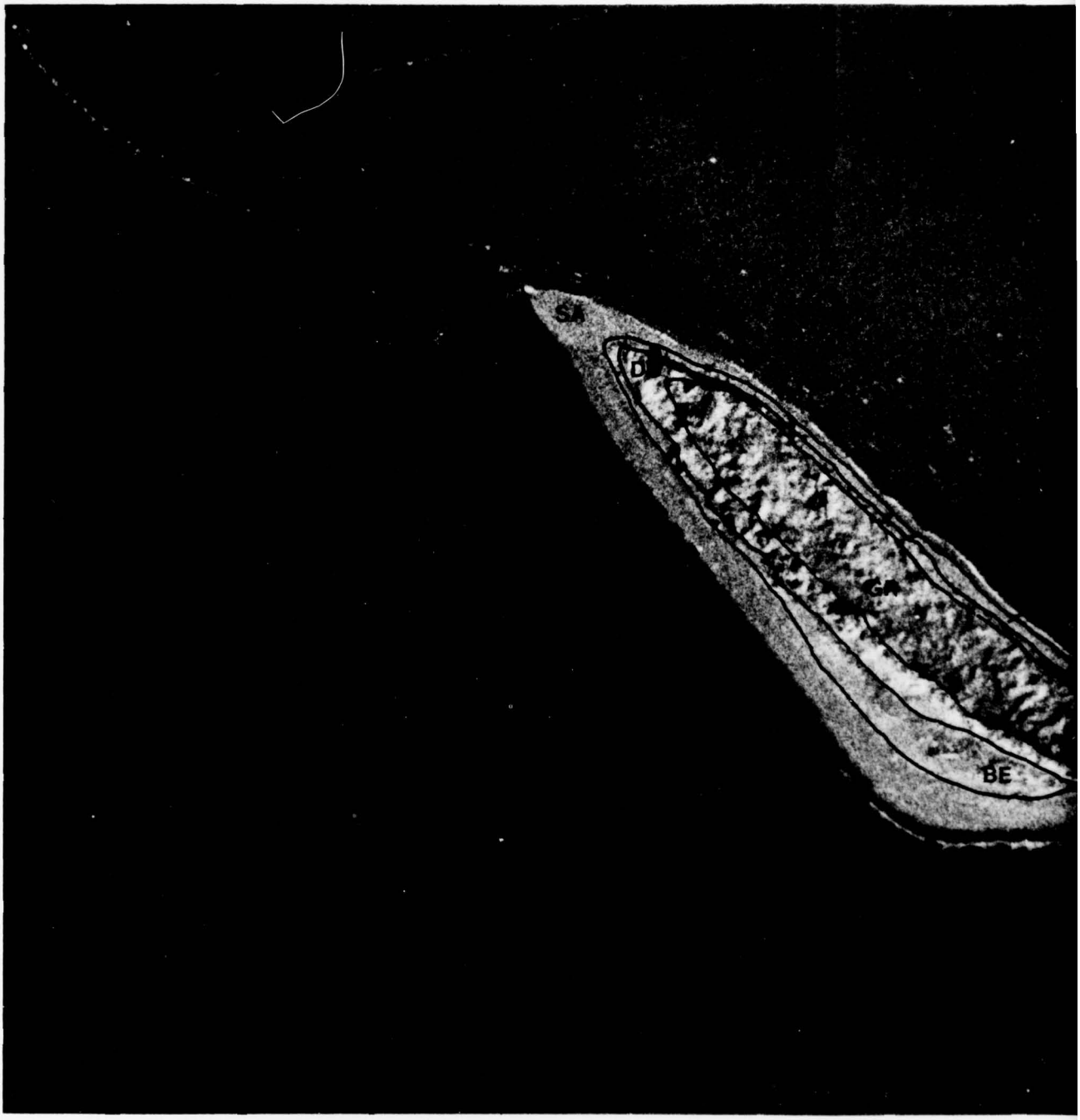
156. A large storm tide plain occupied the extreme eastern portion of the island. This driftwood-scattered upland area had primarily been colonized by a few grasses and herbs. Creeping bentgrass, American dunegrass, shore orache (Atriplex patula), and searocket were the most common species.

157. A high dune separated the storm tide plain and beaches from an interior low grass-herb habitat. The south and west banks of the dune were best developed and significantly protected the interior grassland from wind and water. A dense cover of European beachgrass and American dunegrass had stabilized the dune. Silver bursage (Ambrosia chamissonis) and northern dune tansy (Tanacetum douglasii) were common herb species contributing to the vegetative diversity and stability of the dune.

158. A central grass-herb region dominated by dunegrass and common velvetgrass occurred in a protected interior trough extending along the length of the island and along the narrow eastern spit. Numerous herbs were found within this protected region, but only beach pea occurred in any significant quantities.

Colonial nesting species

159. During the first visit on 26 May, western/glaucous-winged gulls were found nesting throughout all habitats of the island (Figures 28 and 29). Several strip censuses of nests were conducted across the width of the island through representative portions of the colony. Nest counts were extrapolated to the total island nesting area and, when substantiated by counts of adults along the shoreline, the total nesting population was estimated to be 2500 to 3000 pairs.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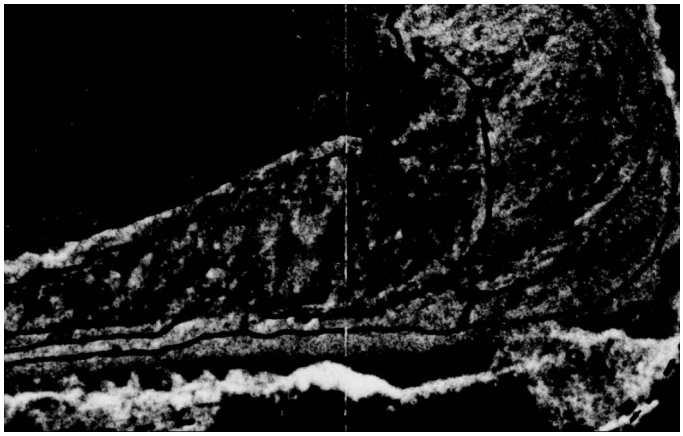

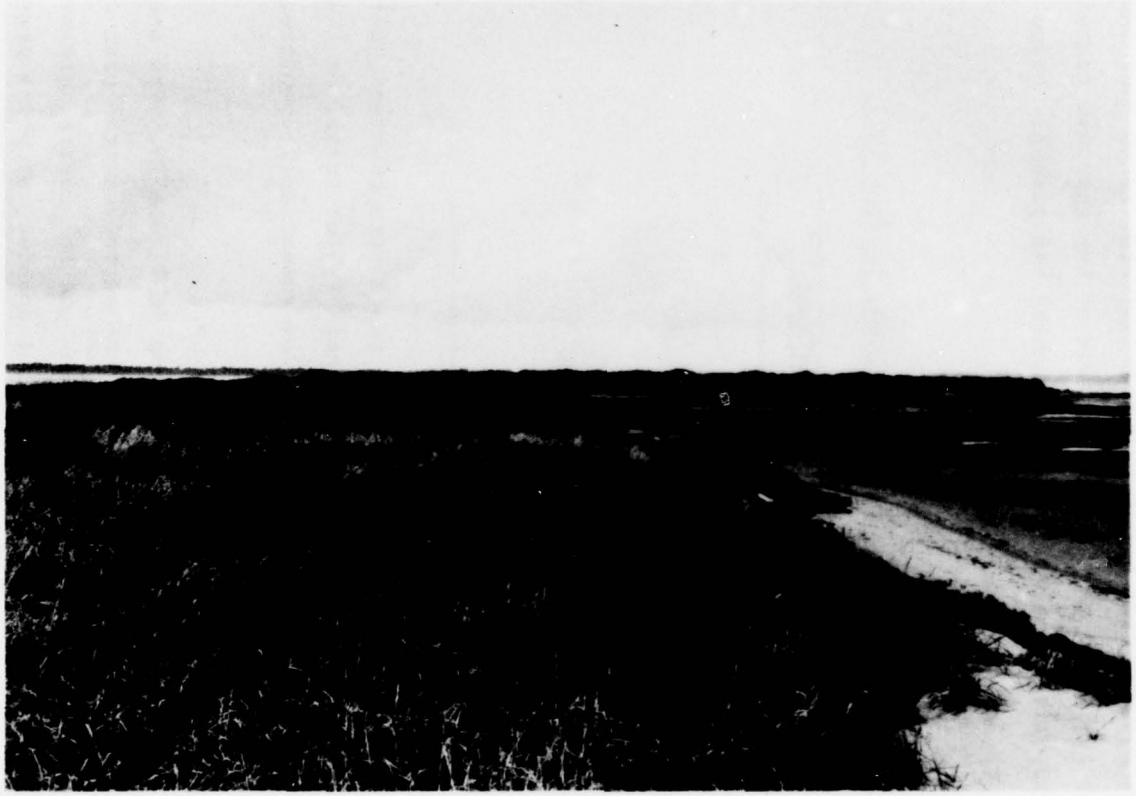

FIGURE 28. GULL NESTING HABITAT OF GOOSE ISLAND,
VIEW TO THE WEST FROM THE NORTHEAST SHORE

160. On 14 June, 63 nests were observed in a representative portion of the colony near the bend at the west end of the island (Table 26). The proportion of inactive nests (3 percent) was far less than that found on East Sand Island (Baker Bay) in this study and for similar gull species on the west coast (Harper 1971, Patten 1974). Of the active nests, it was assumed that egg-laying was complete, as on East Sand Island (Baker Bay), and that nests with one or two eggs had contained chicks which deserted the nest. Thus, hatching had probably begun in 49 percent (30) of the nests.

Table 26

Gull Nest Status on Goose Island, 14 June 1977

		n Chicks/Nest			
		0	1	2	3
n Eggs/Nest	0	2	-	-	4
	1	2	4	8	1
	2	9	2		
	3	31			
Total Nests			63		
Active			61		

161. One month later (14 July), 53 nests were observed. All contained at least one chick and 75 percent held two or three. By the time of the next visit on 17 August, fledging was essentially complete.

Vegetation at the colony

162. Two vegetation transects, shown in Figure 29, were analyzed on Goose Island. Transect 1, 44 m across the narrow central part of the island, crossed two beach and dune habitats and the central grass-herb trough. Table 27 shows that only five plant species, of which American dunegrass was the most abundant, were observed. This species ranged across dune and grass-herb habitats and accounted for 21 percent of the cover and occurred in 61 percent of the test plots.

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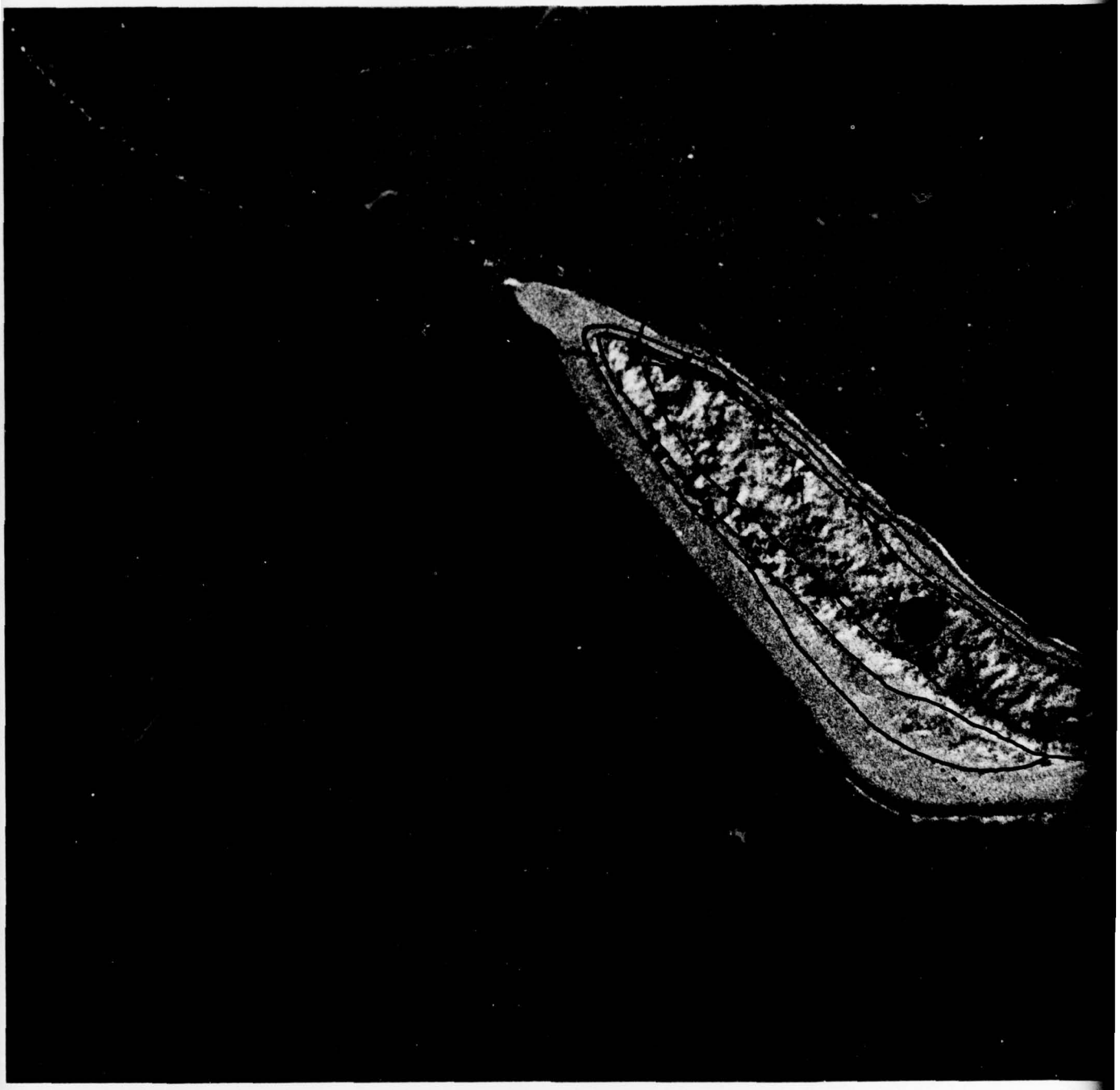

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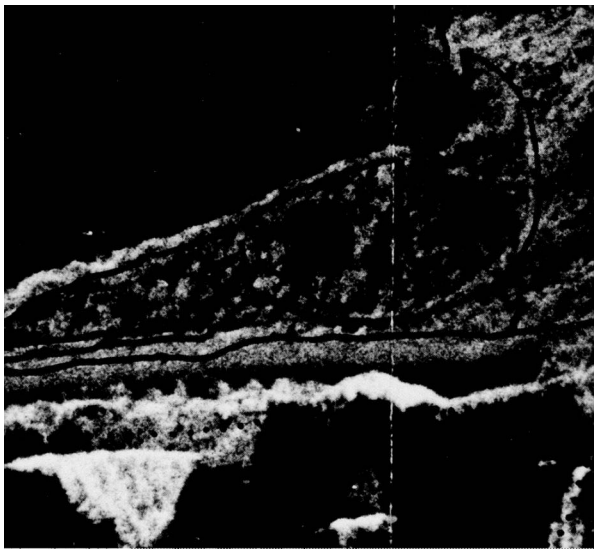


Table 27

Vegetation of Goose Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Transect 1					
Grasses	American dunegrass	105.5	21.1	0- 80	61
	European beachgrass	59.1	13.3	0- 95	30
	Common velvetgrass	35.4	6.5	0- 60	22
Herbs	American searocket	121.8	2.8	0- 40	17
	Silver bursage	78.2	1.1	0- 10	17
Transect 2					
Grasses	American dunegrass	107.2	47.5	15-100	100
	Common velvetgrass	63.2	21.3	0- 65	77
	Creeping bentgrass	23.5	8.5	0- 70	27
	Meadow barley	3.2	1.0	0- 25	4
	Quack grass	2.9	0.8	0- 20	4
Herbs	Beach pea	73.2	3.1	0- 20	39
	Northern dune tansy	37.9	1.7	0- 10	19
	Common sow-thistle	28.2	1.2	0- 10	15
	Yarrow	16.9	0.8	0- 10	8
	Small bedstraw	20.7	0.8	0- 10	12
	American searocket	14.6	0.6	0- 10	8
	Shore orache	8.5	0.4	0- 10	4

163. European beachgrass, although not as well represented across the entire transect, was very dense on the north dune, where it accounted for up to 95 percent cover and 100 percent frequency. Common velvetgrass appeared only in the central lowlands, where it covered 10 to 60 percent of sample plots and appeared as a codominant with dunegrass. Silver bursage was also frequently observed in the lowlands, but accounted for only 1 percent of the ground cover. Distribution of American searocket was limited to beach and low dune habitats. In optimum localities, it accounted for a maximum of 40 percent cover, but averaged 5 to 10 percent.

164. The second transect, 50-m long through the gull colony, extended from the west dune habitat in a west/southwest direction (Table 27). Although 12 plant species were observed along the transect, dunegrass and velvetgrass were the dominant species. Together, these grasses accounted for 69 percent of the ground cover. American dunegrass was observed in every plot, whereas velvetgrass was found in 77 percent of all plots. Creeping bentgrass and beach pea covered approximately 8 and 3 percent, respectively, of sampled quadrats and exhibited a frequency of occurrence of 27 and 38 percent. Other grass-herb species were of minor numerical importance.

Discussion

165. Gulls were first seen nesting on Goose Island in 1953, but no quantitative data were available until 1975 (Penland 1976a). Penland estimated 3500 nesting pairs of western/glaucous-winged hybrids. Wayne Hoffman, of Oregon State University, estimated 2000 nesting gulls on 14 July 1975, and on that day Washington Department of Game personnel inventoried gull nests, eggs, and chicks (Smith and Mudd 1976). In three transects that covered the island, 649 gull nests were analyzed and a total of 866 live chicks and 33 dead chicks were observed. These values, however, were considered underestimates because chicks were observed hiding in dense vegetation. Assuming a conservative 1.33 chicks per nest, the Game Department estimated that the Goose Island colony produced as many as 2700 chicks in 1975. The observations made in 1977 were similar to those reported recently and suggest that this colony is well

established and is producing a substantial annual increment to the total population.

166. Caspian terns did not nest on Goose Island in 1976 or 1977, although this island historically has been a major nesting site for this species. Terns were first seen (presumably nesting) on Goose Island in 1957 (Alcorn 1958). In 1958 an estimated 70 nesting pairs used the island, but no additional counts were made until 1973, when 1000 pairs were estimated. In 1974 that number had dropped to 300 pairs and only 169 nests were counted in 1975 (Penland 1976a). The following spring, only 90 nests were observed (Smith and Mudd 1976).

167. The reduction in breeding numbers apparently was due to erosion of the island, which progressively removed tern nesting habitat. The last of the nesting area was eroded by a series of storms in the winter of 1975/76, and terns are not expected to nest here until suitable habitat is again provided. Although the disappearance of terns renders this island slightly less diverse than Sand Island, it is still an important area for gull nesting and is used for resting and feeding by other colonial nesting seabirds and some passerines.

168. In August 1973, Goose Island, owned by the State of Washington, was given "Natural Area Preserve" status and was withdrawn from sale or lease by the Washington Department of Natural Resources (DNR). Limited protection is provided by a sign on the island which prohibits entry from 1 March to 31 August. Entry permits may be obtained from the DNR Sanctuary Office in Chehalis, Washington.

169. The preserve status was originally enacted to protect the Caspian terns which nested on the island until 1973. Although terns no longer nest there, the status of the island probably will not change since State agencies have become more aware of its importance to other species.

170. This island is in many respects the most stable of those that support gull populations in this area. The well-established vegetation is buffered from storms by driftwood and dunes and it seems likely that this island will continue to support colonial nesting species in the future.

Grays Harbor, Whitcomb Island

Physical characteristics

171. Whitcomb Island is located at the western margin of Grays Harbor, 1.5 km east of a narrow peninsula that separates the southern half of the harbor from the ocean. The island is shown as only a shoal on a NOAA chart published as recently as 1957, and it appears to have become an island within the last decade. In 1977, it was a long narrow island, exhibiting little relief, and much of it was probably covered by high storm tides.

Habitat description

172. Two central dune areas were surrounded by a storm tide plain which gradually receded into a sand flat (Figures 30 and 31). Only four plant species, American searocket, American dunegrass, European beachgrass, and sea purslane, were found on the island (Appendix A, Table A9). Of these, all four occurred primarily in the dune area and searocket and dunegrass were most abundant.

Colonial nesting species

173. Western/glaucous-winged gulls, ring-billed gulls, and Caspian terns were observed nesting on Whitcomb Island in 1977 (Figure 32). On 26 May, 45 western/glaucous-winged gull nests were found, none of which contained young. Most nests held two to three eggs. During the next visit, on 14 July, only chicks were found and all were of medium to large size. Fledging was complete by the last visit, on 17 August.

174. Three ring-billed gull nests were also observed during the May visit and nine nests containing 12 chicks were seen in July. One nest still contained an egg and three of the chicks were less than 3 days old. In August, three dead ring-billed gulls were found; two were entangled in monofilament fishing line.

175. Also on 26 May, 307 Caspian tern nests were counted; most contained three eggs, although 20 held small young. By 14 July, only 40 nests were still active, containing either eggs or chicks less than 1

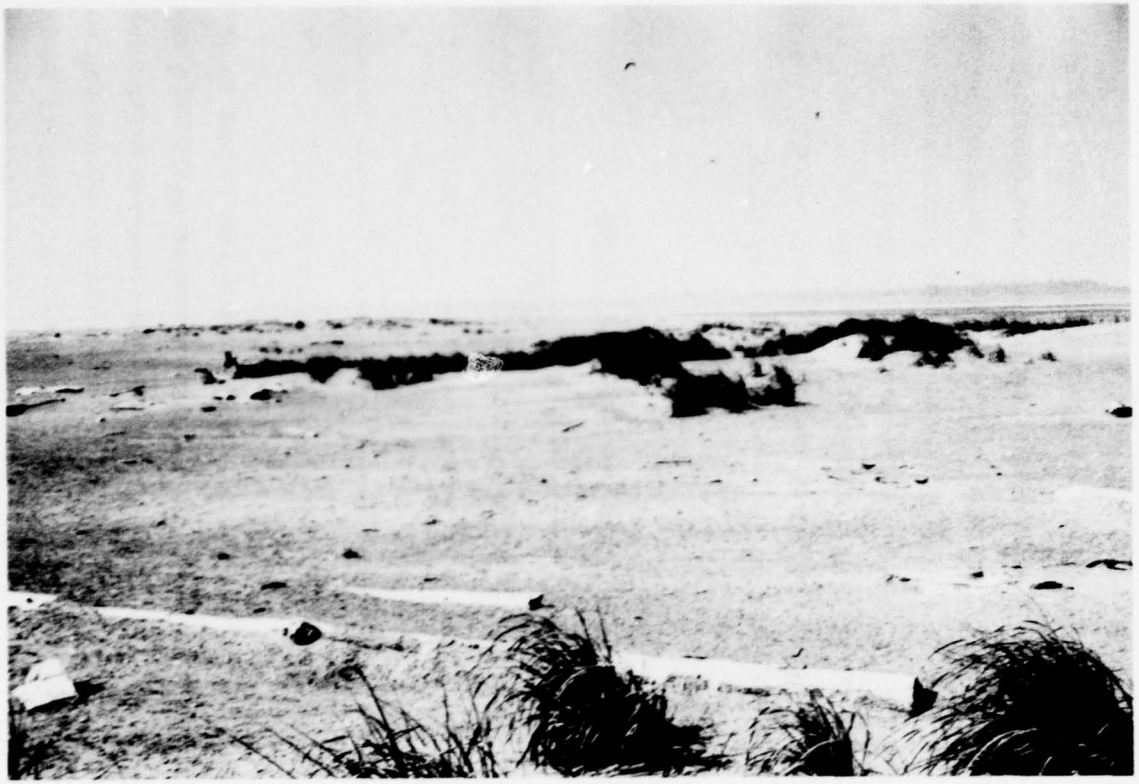


FIGURE 30. WHITCOMB ISLAND STORM TIDE PLAIN AND DUNE HABITATS

week old. Fledged young numbered 79, and 20 dead young (3 banded) and 1 dead adult were found in a search of the colony area. On 17 August, 48 young flightless terns were counted and 17 active nests were found with combinations of chicks less than 1 week old and eggs.

Vegetation at the colony

176. One 162-m transect, extending through both gull colonies and the northern portion of the Caspian tern colony, was examined to describe bird colony vegetation (Figure 32 and Table 28). American dunegrass and American searocket were the only two species of plants observed along the colony transect. Together, these species accounted for only 7 percent of ground cover. Dunegrass was primarily concentrated on one low ridge where it covered from 5 to 90 percent of the plot, whereas searocket was scattered in small clumps on the sandy storm tide plain.

Table 28

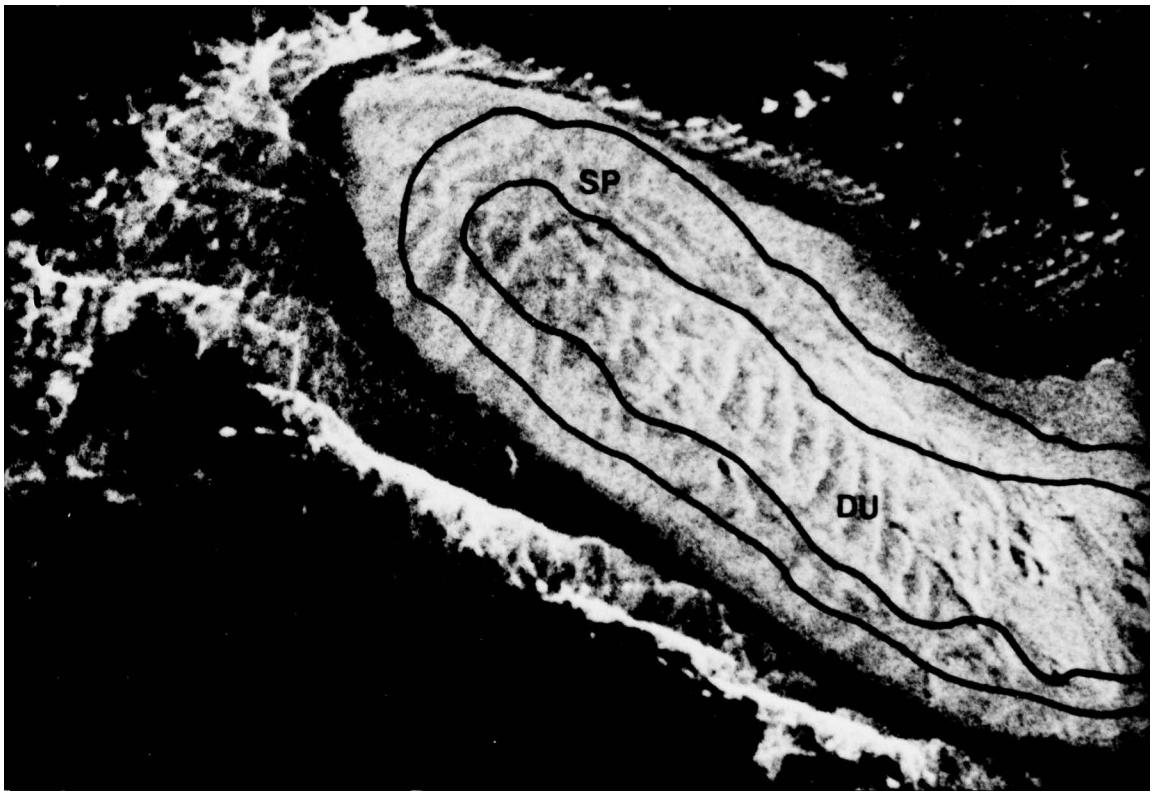
Vegetation of Whitcomb Island

Life Form	Species	Percent Cover		Percent Frequency
		Mean	Range	
Grasses	American dunegrass	6.2	0-80	15
Herbs	American searocket	0.8	0-20	6

Discussion

177. Although gulls did not nest on Whitcomb Island in 1974 (Smith and Mudd 1976), 40 pairs of glaucous-winged gulls were reported nesting the next 2 years (Penland 1976a). Twenty-seven active nests were found in June 1975, and by 8 August little evidence of nesting was observed (Smith and Mudd 1976). The observation of 45 nests in 1977 indicates a stable population on this newly accreted island.

178. Nesting Caspian terns were first seen by a local oyster fisherman, and in August 1974 Smith and Mudd (1976) estimated a 2000- to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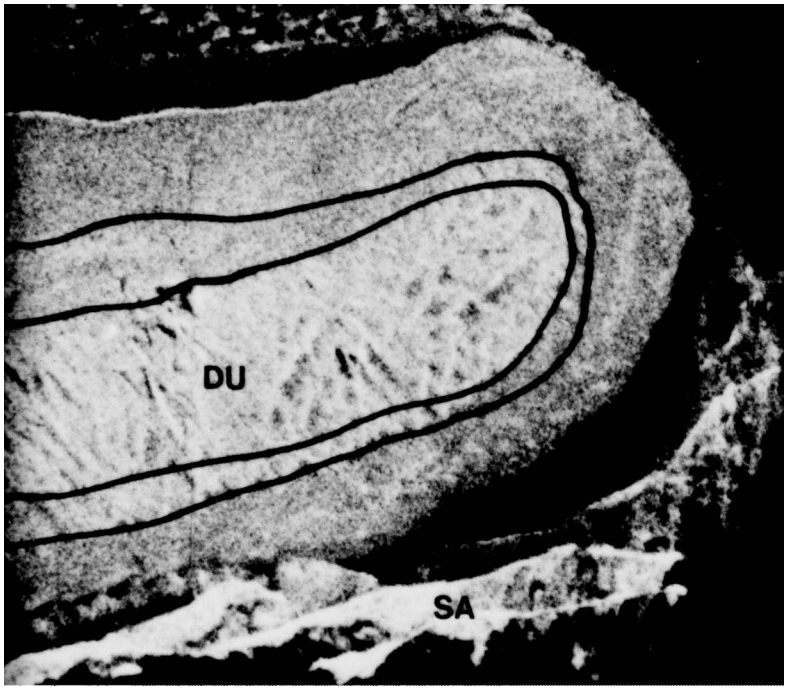
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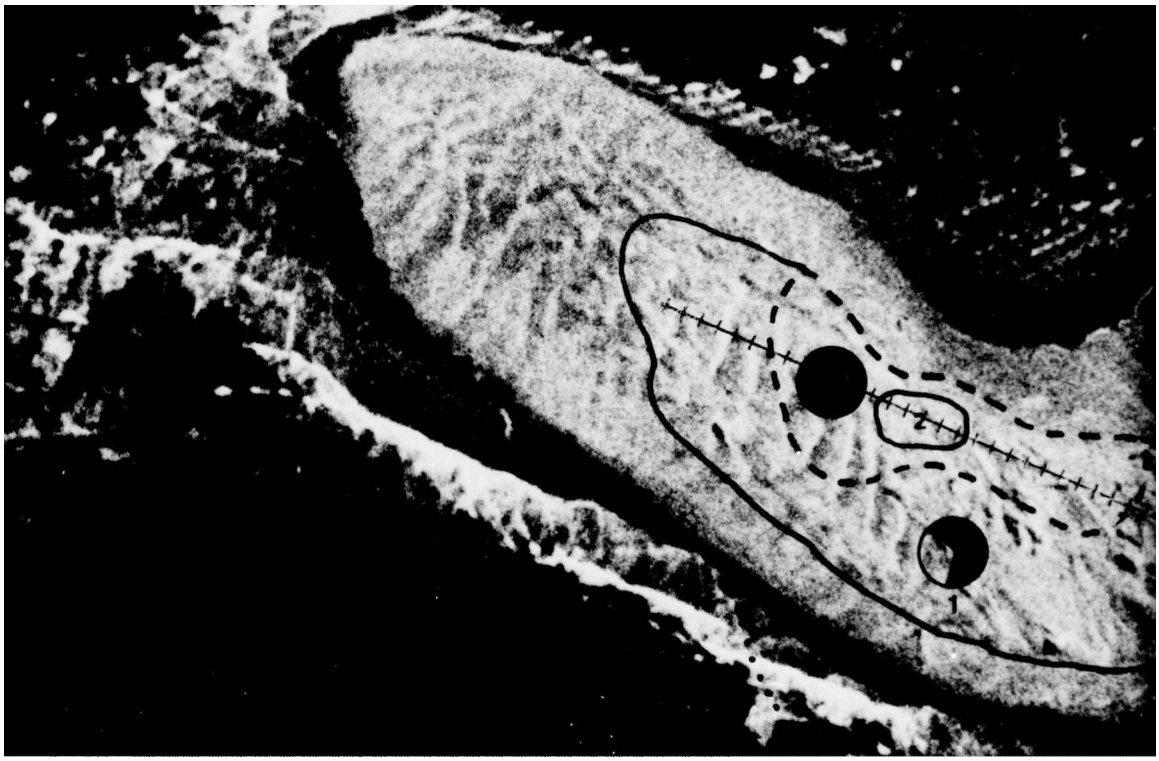
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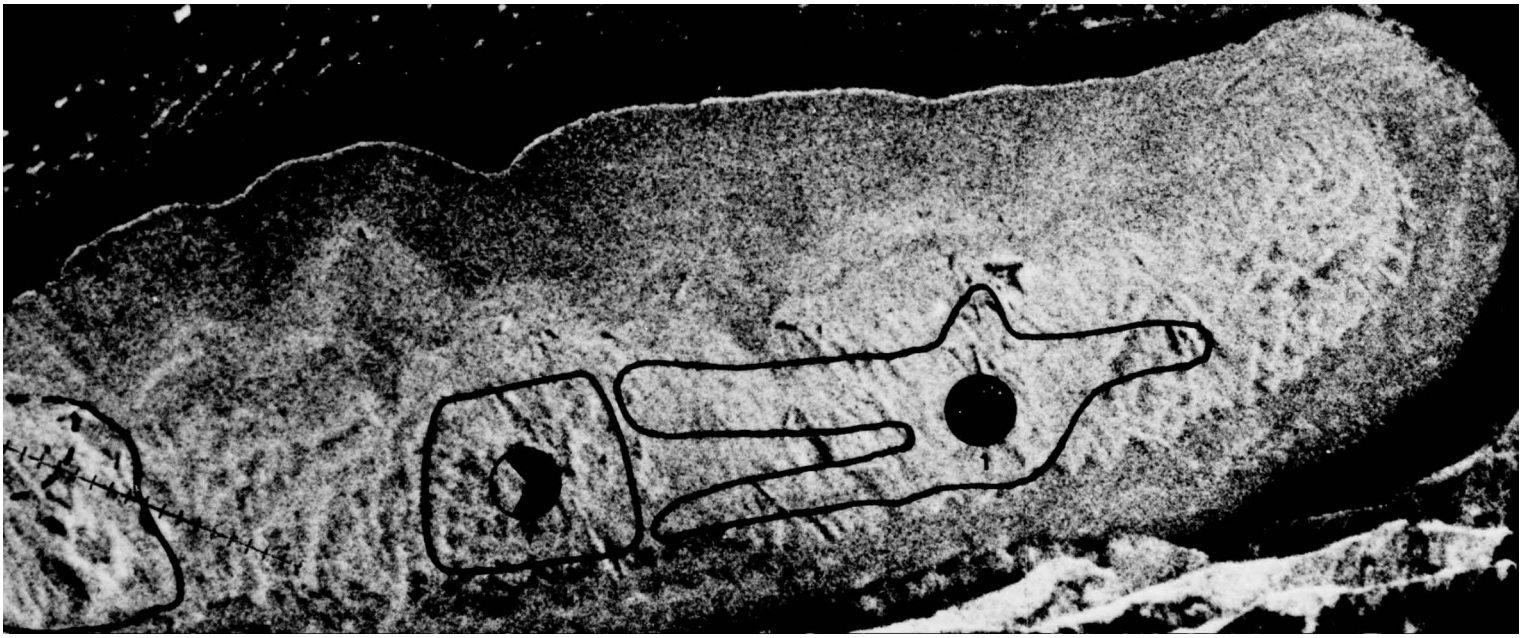
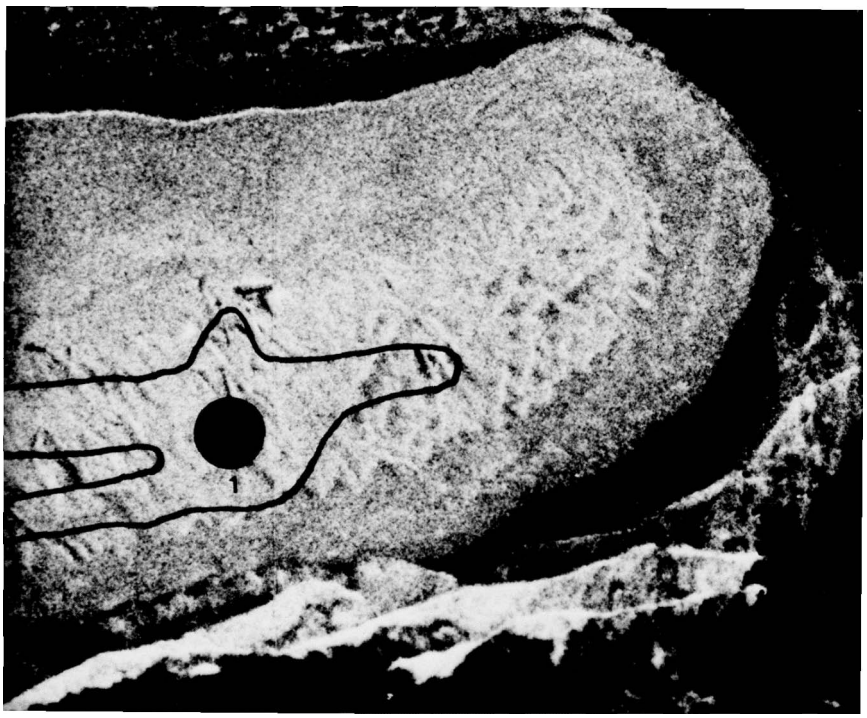




3000-bird colony. At this time, eggs were still being incubated, but chicks of all ages were found.

179. In 1975, the terns arrived between 3 and 8 April, and by 15 April, 50 to 200 adults had arrived at the nesting site. Penland observed 700 active nests by 16 May and estimated 1075 $\pm$50 nests in late May (Smith and Mudd 1976). The mean clutch size was 2.5. It was clear that in 1975 Whitcomb Island had the largest and most successful tern colony in the Pacific Northwest.

180. A reduction in tern nesting apparently has occurred since 1975. In 1977, only 307 nests were observed, which accounts for less than one third of those found in 1975. This may not indicate a decrease in the total population of the area, however. Decreases in the tern populations of either of the three islands in Grays Harbor have been followed by increases on other islands and it is thought that many of the terns move between islands (perhaps even to Willapa Bay) as habitat is altered (Penland 1976b, Smith and Mudd 1976).

181. On Whitcomb Island, the terns tended to nest on lower areas without cover except for large driftwood logs. Gulls nested on the higher ground where searocket achieved moderate density. Both species were concentrated on the leeward (east) side of the island. Nesting habitat may have been chosen at least partially on the basis of relative absence of regular human intrusion, since the south and west sides of the island were most accessible by boat.

182. Whitcomb Island was characterized by sparse cover and by gull and tern nesting areas of restricted size. The island presently undergoes regular changes in shape and will likely remain dynamic in the future. Dredged material could be used to both extend breeding habitat and also stabilize the island by providing suitable substrate for vegetation colonization. The presence of a small boat harbor in the vicinity of the island, however, will always pose a threat to any colonial nesting species.

Duwamish River, Kellogg Island

Physical characteristics

183. Kellogg Island, with an area of approximately 6 ha, is one of the largest islands in the lower Duwamish River estuary (Figure 33). It is approximately 550 m long, 250 m wide at its widest point, and the northern half is encircled by a 1-to 2-m high dike. Heavy industrial activity occurs adjacent to the site. Seaboard Lumber Company uses the channels surrounding the northern, eastern, and western sections of the island to store logs prior to their processing at the mill immediately north of the island. Logs 10 to 20 m long are stored within booms moored to permanent dolphins surrounding the island. Portland Cement Company, which processes and ships cement products, is located 30 m south of the island and uses the narrow channel south of the island to store barges.

184. Water surrounding the island is relatively shallow, and an extensive mud flat is exposed to the west and north during low tide. To the west, this flat extends to the mainland. On the east, the Georgetown reach of the river has been repeatedly dredged from 1910 through 1973, and the river is deeper closer to the shore. The northern one half of the island is relatively level, but in the south it gradually rises 10 to 15 m and then drops steeply toward the shoreline of the north channel. Elevations are 1 to 2 m above mhhw at the northern border and 10 m above mhhw at the southern ridge.

185. The subsurface soil was originally the result of tidal marsh processes and therefore exhibits localized concentrations of peat and organic silt material. Because of the relatively undisturbed nature of the island and the dense colonization of sedges and rushes, the organic nature of the subsurface soils in the northern section of the island remain. In 1973, portions of the island received 45,900 m^3 of dredged material, including cement and other man-made conglomerates and fine dredged material sands (Seattle Department of Community Development 1976). Exposed soils in cuts and along channel banks reveal sand, silt, and gravel as dominant soil components.

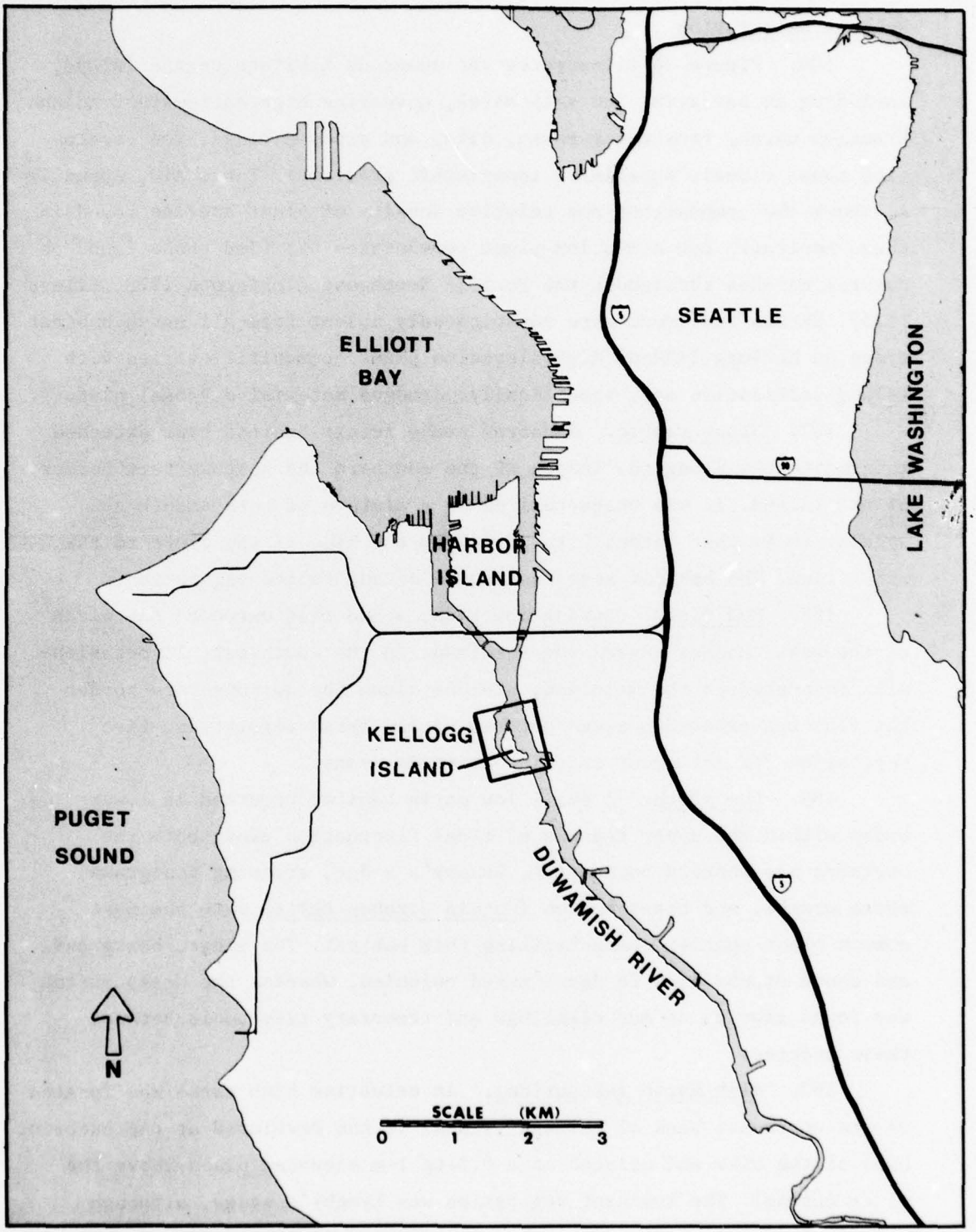


FIG. 33 DUWAMISH RIVER STUDY AREA

Habitat description

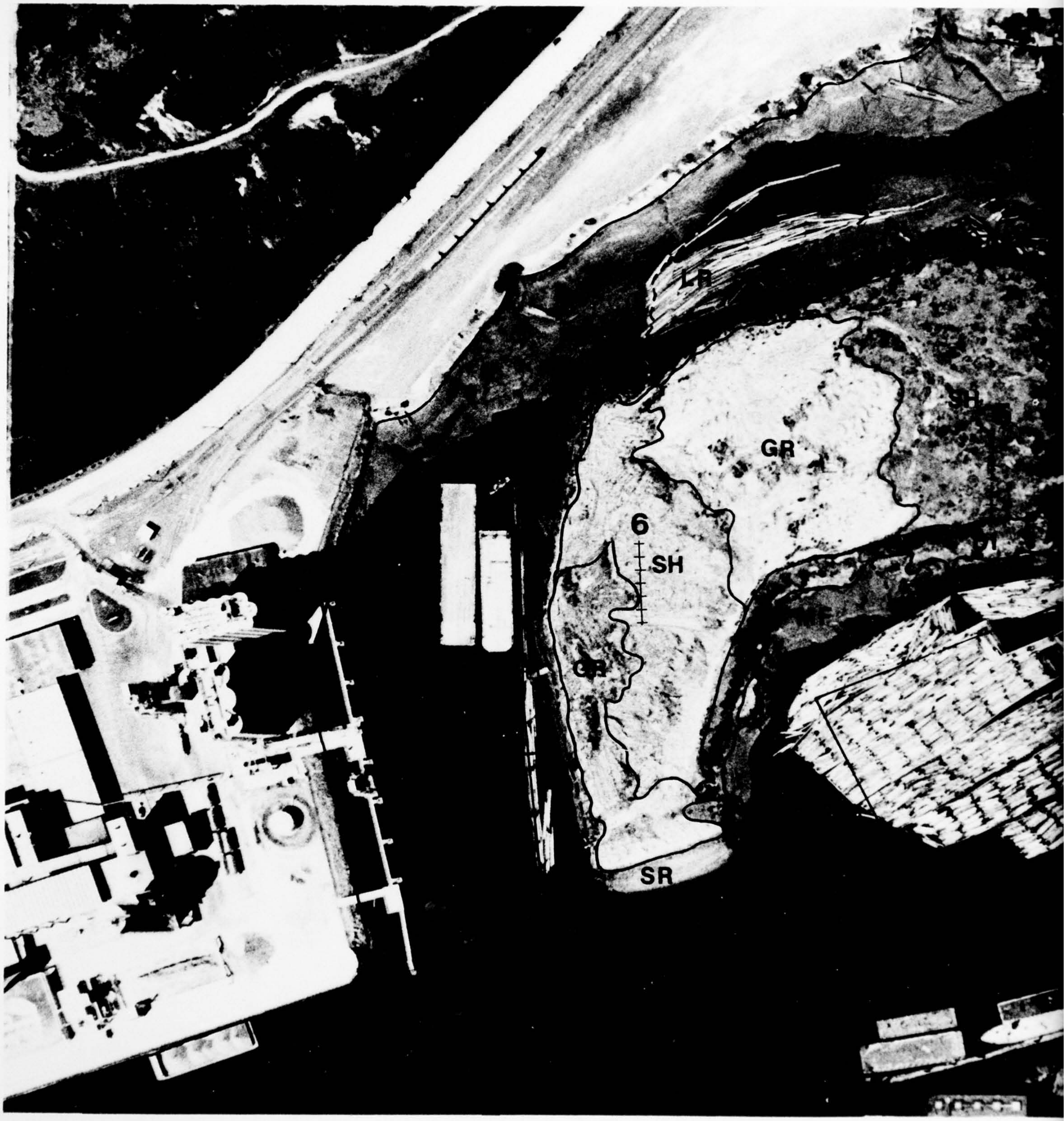
186. Figure 34 illustrates the numerous habitats on the island, including an estuarine low salt-marsh, estuarine high salt-marsh, inland brackish marsh, freshwater marsh, dike, and exposed ridge. The vegetation types closely paralleled topographic gradients. Table A10, Appendix A, shows the composition and relative density of plant species found in these habitats. Low elevation plant communities typified those found on coastal marshes throughout the Pacific Northwest (Jefferson 1975, Eilers 1975). Shrubs and trees were conspicuously absent from all marsh habitat types on Kellogg Island. High elevation plant communities varied with island utilization and, specifically, dredged material disposal history.

187. Stone rubble. A narrow stone rubble habitat type extended intermittently along the length of the southern and southwestern border of the island. It was characterized by a mixture of both smooth and angular rocks that extend 2 to 10 m from the base of the bluff to the water line. The habitat zone was devoid of any rooted vegetation.

188. Mud flats. During low tide, a mud flat extended the width of the west channel toward the mainland. In the southwest, it occasionally connected to the mainland, whereas along the northwestern border the flat was exposed between patches of low marsh vegetation. Live vegetation did not occur in this intertidal zone.

189. Low marsh. A small low marsh habitat occurred in lower banks within the upper reaches of tidal fluctuation along both the northern and western boundaries. Lyngby's sedge, creeping bentgrass, shore orache, and brass button (Cotula coronopifolia) were the most common plant species characterizing this habitat. The sedge, bentgrass, and shore orache grew in dense mixed colonies, whereas the brass button was found growing on mud clearings and temporary tide pools between these species.

190. High marsh (estuarine). An estuarine high marsh was located on the northeast bank of Kellogg Island. It had developed at the exterior base of the dike and existed as a 0.5- to 1-m elevated plain above the river channel. The dominant vegetation was Lyngby's sedge, although



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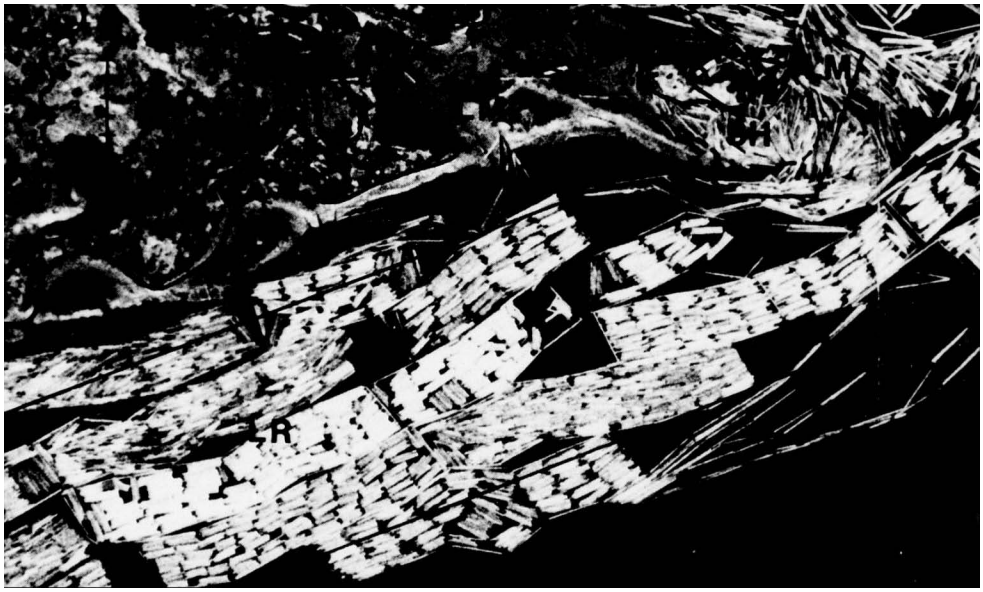
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Baltic rush, creeping bentgrass, and saltgrass (Distichlis spicata) also occurred.

191. High marsh (brackish). Within the boundaries of the dike, an extensive brackish marsh covered the northern fourth of the island. This habitat exhibited a uniform rush meadow of Baltic rush, soft rush (Juncus effusus), and common spike-rush (Eleocharis palustris). In depressions and regions of poor drainage, brass button, shore orache, Pacific silverweed, sea plantain (Plantago maritima), and creeping bentgrass were established. Saltgrass was common near saltwater seepage holes.

192. Grass-herb. The grass-herb habitat occurred where the island had most recently been disturbed. It was characterized by areas of exposed soil, sand, rock accumulations, old roadways, and a sparse but diverse vegetative cover. Two geographically and vegetatively distinct grass-herb habitats existed. The first, located in the interior of the island, was vegetatively complex. It was dominated by the introduced perennial common velvetgrass, bentgrass, *and* red fescue. Scattered among the grasses were numerous introduced weed species, including sheep sorrel (Rumex acetosella), kitchen sorrel (R. acetosa), meadow goldenrod (Solidago canadensis), fireweed (Epilobium angustifolium), Watson's willow-herb (E. watsonii), and northern dune tansy. The second grass-herb habitat, located in the southernmost portion of the island, was vegetatively sparse. Its primary components were dense stands of white sweet-clover (Melilotus alba) and velvetgrass, with fireweed and sheep sorrel occupying the driest locations.

193. Shrub. The shrub habitat type existed as a flat, wide band extending east/west across the center of the island. Its primary plant components included an overstory of red alder and Scot's broom, and a dense understory of common horsetail. Velvetgrass occurred as scattered clumps throughout this habitat.

194. Dike. The dike was an important topographic and vegetative feature of Kellogg Island. It encircled all but the southern boundary and varied in height from less than 1 m above the island's interior in the south to several meters along the east and west margins. The width

of the dike also varied, from less than 1 m in the north to more than 3 m along the east and west boundaries. The dike was vegetatively and structurally the most diverse habitat found on the island. Numerous grass, herb, shrub, and tree species were mixed, and uniform stands were found along its sides and ridge. Foremost among the more abundant species were velvetgrass, bentgrass, yarrow, Himalayan blackberry, red elder, red alder, Pacific madrone (Arbutus menziesii), and Scouler willow (Salix scouleriana).

Vegetation

195. Six transects were analyzed on Kellogg Island to describe the vegetation along habitat types (Figure 34). The first transect (Table 29) extended from the Duwamish River intertidal zone to the interior of the island and was perpendicular to the dike of the north boundary. This revealed that Lyngby's sedge was the most abundant species outside the dike. It occurred in 50 percent of the plots and exhibited a mean cover of 14 percent. Seaward but adjacent to the dike and extending across to the interior, saltgrass was the most important component. This species was present in 31 percent of the plots and exhibited a mean cover of 16.7 percent, although in the center of the transect it formed dense mats covering entire sampling plots. Creeping bentgrass and Pacific silverweed became important plant species within the brackish high marsh south of the dike. Bentgrass accounted for 42.8 percent of the cover and was observed in 58 percent of the transect plots, whereas silverweed accounted for 8.8 percent cover and was found in 27 percent of the sample plots. Douglas' aster (Aster subspicatus) and yarrow were the only other plants of any importance, accounting for 3.6 and 1.7 percent cover and occurring in 23 and 15 percent of our sample plots.

196. The second transect extended across the interior high marsh west from the east dike through a dense stand of common reed (Phragmites australis)approximately 20 m across. Mean cover of vegetation averaged greater than 90 percent and was distributed only among grasses and herbs; no shrub or tree species were observed (Table 30). The most abundant and ecologically dominant species were common reed and creeping

Table 29

Low and High Marsh (Transect 1) Vegetation of Kellogg Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	Creeping bentgrass	137.4	42.8	0-100	58
	Saltgrass	63.6	16.7	0-100	31
Sedges	Lyngby's sedge	--	14.0	0- 95	50
	Soft rush	--	--	0-T	4
Herbs	Pacific silverweed	103.9	8.8	0- 80	27
	Douglas' aster	60.9	3.6	0- 50	23
	Yarrow	35.2	1.7	0- 25	15
	Sea plantain	--	--	0-T	4
	English plantain	--	--	0-T	4
	Field milk-thistle	--	--	0-T	12
	Shore orache	--	--	0-T	4
Other	Bare ground	--	16.1	0- 75	23

* T: Trace

Table 30

High Marsh (Transect 2) Vegetation of Kellogg Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	Common reed	113.9	50.4	0-100	62
	Creeping bentgrass	70.0	26.0	0- 95	46
	Saltgrass	82.6	2.3	0- 40	12
	Common velvetgrass	3.5	0.2	0- 10	4
Sedges	Baltic rush	116.9	6.7	0-100	19
	Soft rush	58.4	3.8	0- 15	8
	Lyngby's sedge	24.7	0.2	0- 5	8
Herbs	Sea plantain	77.9	0.8	0- 15	15
	Douglas' aster	52.8	0.4	0- 10	15
	Yarrow	34.8	0.2	0- 5	12
	Pearly-everlasting	34.8	0.2	0- 5	12
	Hawkweed	--	--	0-T	4
Other	Litter	--	0.8	0- 20	4
	Bare ground	--	--	0- 10	4

* T: Trace

bentgrass. The common reed formed an intermittent marsh and completely dominated the middle of the transect, exhibiting 100 percent frequency and cover. Before and after the reed marsh, bentgrass dominated vegetative composition; it occurred in every plot and exhibited an average cover of greater than 60 percent. Several marsh species, including Lyngby's sedge, soft rush, and Baltic rush occurred mixed with herbs such as sea plantain, Douglas' aster, pearly-everlasting (Anaphalis margaritacea, and hawkweed (Hieracium sp.). These species, however, accounted for less than 25 percent cover.

197. The third transect extended across the west dike toward the center of the island. Low-growing grasses, rushes, sedges, and herbs, in addition to larger shrubs and trees, were characteristic (Table 31). Red alder, Pacific madrone, red elder, and European mountain-ash (Sorbus aucuparia) formed an open canopy under which common velvetgrass and creeping bentgrass were dominant ground cover species. Velvetgrass was more commonly observed (82 percent of plots) and accounted for an estimated 19.1 percent cover, whereas the bentgrass only occurred in 36 percent of the plots, but nevertheless accounted for 15.5 percent cover. Hawkweed, the most ubiquitous herb, was observed in 27 percent of the sampled plots and accounted for 2.3 percent of the cover. Other herbs included white clover (Trifolium repens), exhibiting 1.8 percent cover and 9 percent frequency, and English plantain (Plantago lanceolata), with 0.4 percent cover and 9 percent frequency. Baltic rush and Lyngby's sedge were infrequently observed.

198. West from the east dike to the center of the island, Transect 4 showed that the vegetation was a patchwork of single species populations (Table 32). On the dike, Himalayan blackberry dominated by occurring in all of the plots and occupying 100 percent of all plots, even though for the entire transect it occurred in only 31 percent of plots and averaged 19.6 percent cover. At lower elevations, a dense common reed population dominated the midsection of the transect, being observed in all central plots and accounting for 100 percent cover, although within the total transect it accounted for 46 percent frequency and 42 percent cover. West of the reed was a community dominated by common

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Table 31

West Dike (Transect 3) Vegetation of Kellogg Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grasses	Common velvetgrass	124.7	19.1	0- 50	82
	Creeping bentgrass	75.3	15.5	0-100	36
Sedges	Baltic rush	100.0	0.4	0- 5	9
	Lyngby's sedge	100.0	0.4	0- 5	9
Herbs	Hawkweed	111.1	2.3	0- 20	27
	White clover	60.0	1.8	0- 20	9
	English plantain	28.9	0.4	0- 5	9
Shrubs and Trees	Red alder	99.?	4.5	0- 30	13
	Pacific madrone	43.4	1.4	0- 15	9
	Coast red elder	28.5	0.4	0- 5	9
	European mountain-ash	28.5	0.4	0- 5	9
Other	Litter	--	21.8	0- 90	36

Table 32

East Dike and High Marsh (Transect 4) Vegetation of Kellogg Island

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grasses	Common reed	94.2	20.8	0-100	31
	Common velvetgrass	74.6	6.5	0- 20	62
	Red fescue	17.0	3.1	0- 40	8
	Creeping bentgrass	14.2	0.4	0- 5	15
Sedges	Lyngby's sedge	200.0	3.8	0- 50	8
Herbs	Common horsetail	140.0	42.0	0-100	46
	Field milk-thistle	34.3	1.5	0- 5	31
	Canadian thistle	16.8	0.8	0- 10	15
	Meadow goldenrod	8.9	0.4	0- 5	8
Shrubs	Himalayan blackberry	151.1	19.6	0-100	31
	Scotch broom	98.9	3.8	0- 40	15

horsetail. It entirely covered the western transect plots. Occurring as scattered clumps between these three major plant concentrations were velvetgrass, red fescue, bentgrass, field milk-thistle (Sonchus arvensis), Canadian thistle (Cirsium arvense), meadow goldenrod, and Scot's broom.

199. The most numerous species were observed along the fifth transect (Table 33). Thirteen grass-herb and one shrub species were observed, forming a mosaic along most of this 42-m transect. Velvetgrass was observed most frequently in sample plots (57 percent of the time); however, all but two of the remaining species were also well represented. Although red fescue, Himalayan blackberry, and white sweet-clover formed dense localized populations and accounted for 70, 100, and 100 percent of the vegetative cover, respectively, other species were scattered along the transect, each individually occupying less than 40 percent of any sample plot. An unvegetated section characteristic of the dryer internal areas of the island was found at the eastern end of the transect. Bare ground in this region occupied between 40 and 90 percent of sampled plots.

200. The vegetation colonizing the 1973 dredged material deposit was quantified by the sixth transect (Table 34). This short 12-m transect, immediately west of a primitive roadbed, was only sparsely vegetated. On the average, cover was less than 55 percent of plot area, although range of coverage varied from 5 to 100 percent. Plant species were primarily introduced early successional grasses and herbs. The most common species observed were red fescue, white sweet-clover, northern dune tansy, and goldenrod, occurring with a frequency of 67, 67, 50, and 50 percent, respectively.

Discussion

201. There is no history of colonial nesting waterbirds breeding on Kellogg Island and none were observed in 1977. The log rafts surrounding the island are used extensively for resting by great blue herons and other species. Up to 10 herons were observed there and approximately 100 glaucous-winged gulls and 25 Bonaparte's gulls were seen at one time. Herons also feed on the tidal flats to the west and north of the island.

Table 33

East Dike and Shrub Habitat (Transect 5) Vegetation of Kellogg Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	Red fescue	78.8	13.6	0- 70	38
	Common velvetgrass	54.5	4.1	0- 20	57
	Silver hairgrass	40.8	6.3	0- 40	24
	Creeping bentgrass	15.6	0.7	0- 5	19
	Bluegrass	10.3	0.9	0- 20	10
Herbs	White sweet-clover	68.6	8.6	0-100	14
	Meadow goldenrod	42.4	2.5	0- 20	33
	Pearly-everlasting	36.6	2.1	0- 20	29
	Lambsquarter	25.8	0.5	0- 5	29
	Field milk-thistle	19.4	0.7	0- 10	19
	Yarrow	7.2	0.5	0- 10	5
	Canadian thistle	--	--	0-T	10
	Pacific silverweed	--	--	0-T	5
Shrubs	Himalayan blackberry	200.0	16.9	0-100	33
Other	Bare ground	--	26.7	0- 90	48

* T: Trace

Table 34

Shrub Habitat (Transect 6) Vegetation of Kellogg Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grasses	Red fescue	118.8	2.1	0- 25	67
	Fescue	59.4	1.7	0- 10	17
	Creeping bentgrass	21.8	0.2	0- 5	17
	Silver hairgrass	--	--	0-T	17
Herbs	White sweet-clover	97.2	13.3	0- 30	67
	Northern dune tansy	51.4	5.0	0- 25	50
	Meadow goldenrod	51.4	5.0	0- 10	50
	Lambsquarter	--	--	0-T	17
	Pearly-everlasting	--	--	0-T	17
	Field milk-thistle	--	--	0-T	17
Other	Bare ground	--	46.7	0- 95	67

* T: Trace

202. An estimated 8 to 15 pairs of spotted sandpipers (Actitis macularia) were observed nesting in the hills at the south end of the island. Killdeer (Charadrius vociferus) were also heard and seen and it is likely that they nested in the sparsely vegetated areas in the southwest corner of the island. The nests of five pairs of mallards (Anas platyrhynchos) were seen along the east dike and in the high marsh habitat in the north. Two adult and seven immature California quail (Lophortyx californicus) were observed near the west dike and it is believed that they nested along the west margin of the dike in the shrub habitat dominated by Scotch broom.

203. The vegetation of Kellogg Island was a mixture of low diversity wetland and high diversity upland plant associations. Wetlands were dominated by homogeneous stands of a few marsh grasses, rushes, and sedges, and uplands were a mosaic of vegetation comprised of numerous introduced species of grasses, herbs, shrubs, and trees. Marsh associations appeared stable in the sense that they formed an edaphic climax; species currently occupying wetland sites were competitively excluding new colonizers and simultaneously regenerating successfully.

204. Upland communities were seral. The large expanses covered by a variety of grasses, herbs, and occasional shrubs should provide the substrate and changes in microclimatology necessary to permit the further dispersal of shrubs and the succcesful colonization by trees. The rate of this change is topographically determined, as shown by the transect data. Dike and ridge vegetation, for example, already supported localized stands of shrub and early successional tree species, whereas the flatter lower interior of Kellogg Island supported perennial grass and herb species.

205. Kellogg Island is owned by the Port of Seattle and has been considered an excellent site for the disposal of dredged materials from the Duwamish River. Recently, however, considerable public sentiment has been expressed to stop dredged material disposal and enhance the island as a natural preserve in the center of the industrialized Duwamish basin. Indian artifacts have recently been discovered on the mainland just west of the site, and the island's future is yet to be determined.

206. Due to its proximity to human disturbance, inland location, and habitat types, Kellogg Island does not offer suitable nesting habitat for colonial nesting waterbirds. The island appears to be an important feeding and resting area for great blue herons and the log rafts provide protected areas for gulls and waterfowl.

Port Gardner Bay, Jetty Island

Physical characteristics

207. In 1894, the Federal government adopted a plan to construct a freshwater harbor about 1.6 km long at the mouth of the Snohomish River (Figure 35). Jetty Island was created by the dredged material of this project and was completed in 1903. Rapid siltation from the Snohomish River requires frequent dredging, which has occurred in 1916, 1921, 1938, 1945, and 1969. In 1977, Jetty Island had an area of approximately 81 ha at high water and had extensive mudflats on the bay (west) side. Parks (1973) noted that the west side of the island had extended because of accretion and sedimentation of heavy suspended materials. Due to the difference in dredged material particle size, deposits extending from the island consist of increasingly finer material which is eventually displaced by organic mud. The island is occasionally used by humans during the summer months. Occasional waterfowl hunting occurs in the autumn.

208. The island topography was relatively flat; elevation was highest in the northern shrub-covered uplands and graded toward a large central and southern grass-covered lowland. Most of Jetty Island is composed of fine gray sand containing little organic matter (Parks 1973). Because the dredged material originated from different areas, soil composition in some locations is variable and has resulted in a heterogeneous mix of soil types and vegetation. Soils underlain by clay have resulted in the formation of an upland marsh. The western shoreline of the island showed typical ocean sand beach development and associated vegetation.

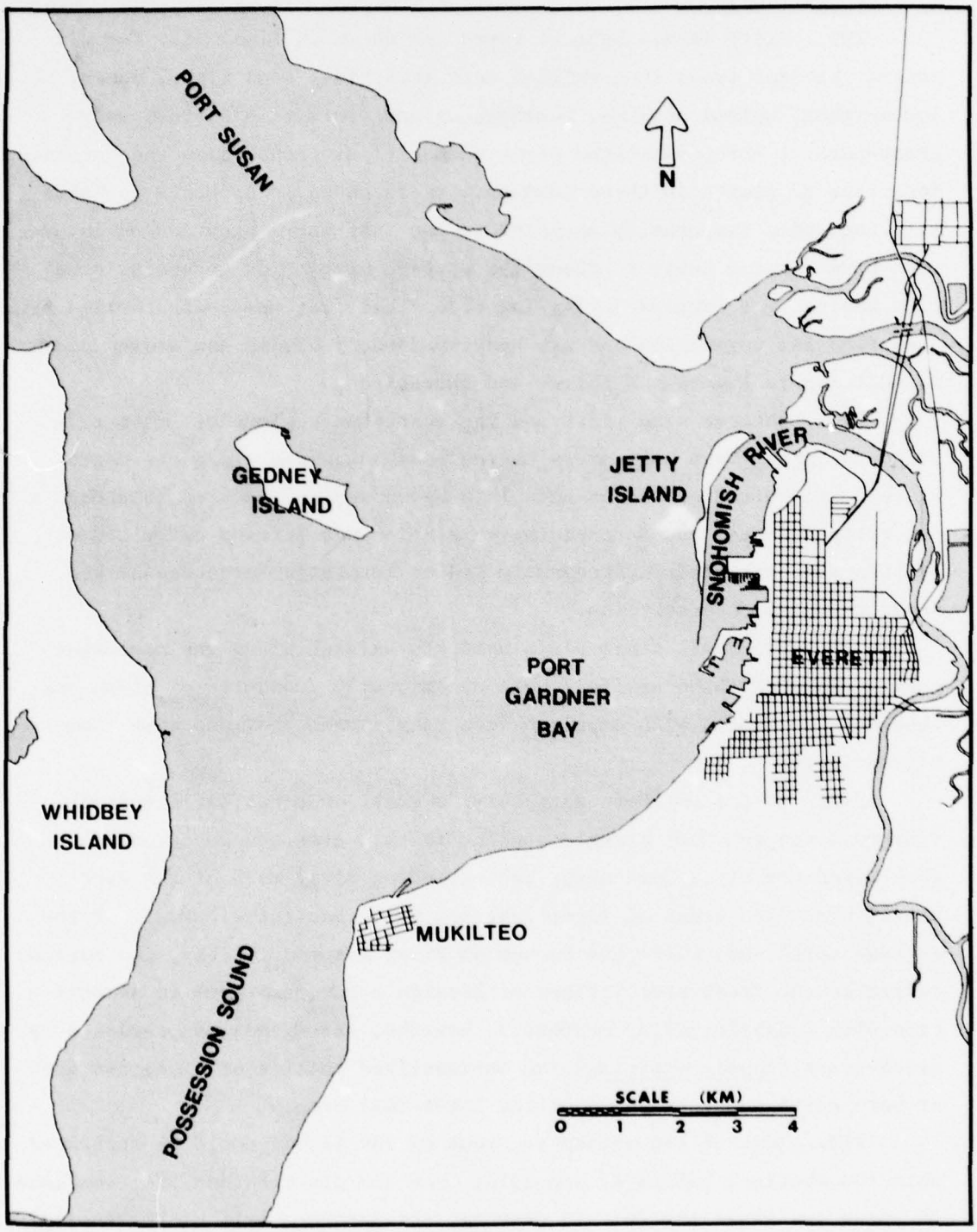


FIG.35 PORT GARDNER BAY STUDY AREA

Habitat description

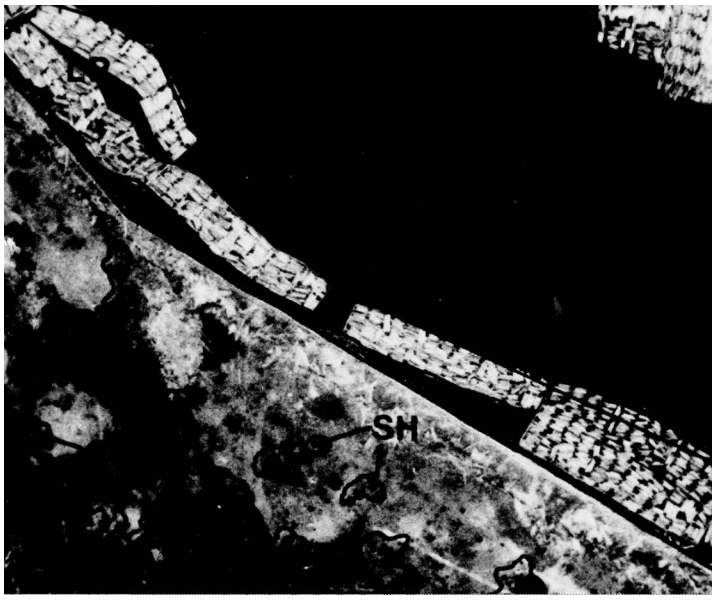
209. Jetty Island habitat types are shown in Figure 36. The six general habitat types that existed were intertidal sand flats, dunes, low marshes, upland marshes, beaches, upland storm tide plains, and grass-herb or shrub-dominated plant communities. Composition and relative densities of plants in these communities are shown in Appendix A, Table A11. Log rafts temporarily anchored to the east shore provided an important bird resting habitat. Along the western margin, an extensive sand flat habitat was exposed during low tide. This flat was characterized by free-floating vegetation and was heavily used by diving and wading ducks in addition to numerous seabirds and shorebirds.

210. Between sand flats and the scattered regions of storm tide plain and grass-herb habitat, a narrow beach extended along the northwestern two thirds of the island. This beach was unvegetated, although a drift line of dead and decomposing vegetation was left by daily tides. In this area, shorebirds frequently fed on intertidal crustaceans and other stranded invertebrates.

211. Two small storm plain habitats existed along the southwest coast. Although these habitats were occasionally inundated or blown out, they were vegetated with American dunegrass, which provided some amount of stability.

212. At the northern periphery, a small dune habitat occurred. Dunegrass was the most prevalent plant in this area and appeared to have stabilized the site. Here also, but extending along much of the east shore, scattered areas of intertidal low marsh habitat occurred. At the extreme north end, where the Snohomish River entered the bay, low marshes reflected the freshwater influence. Seaside arrowgrass grew in association with Lyngby's sedge. Southward, however, arrowgrass was replaced by ditch-grass (Ruppia maritima). An unidentified species of bluegrass grew at both north and south ends of the intertidal area.

213. Most of the upland sections of the island could be separated into two distinct habitats, depending upon the distribution and abundance of shrub and grass species. In general, the northern half of the island was dominated by extensive patches of Scot's broom interspersed with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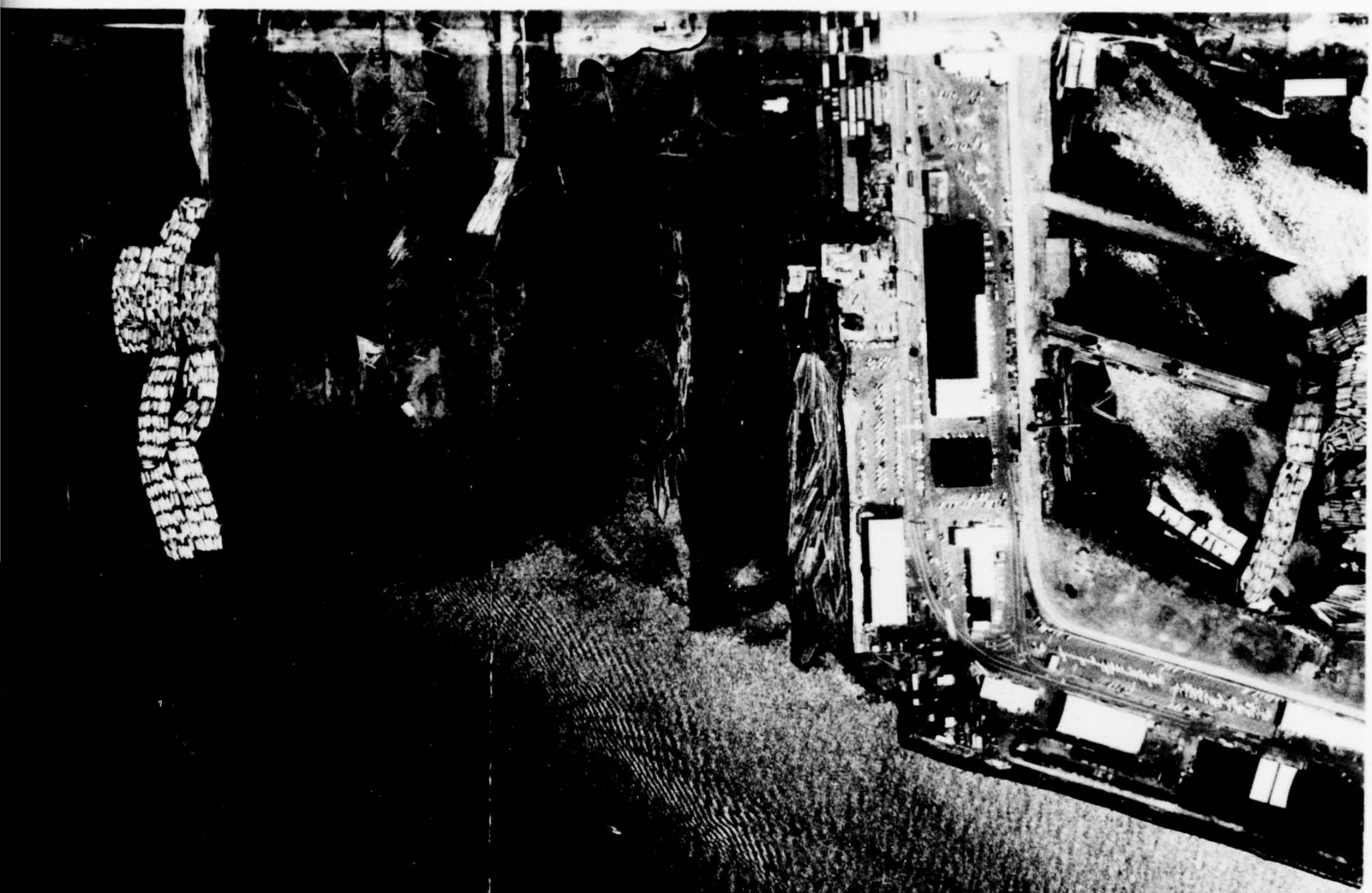


partial clearings covered by silver hairgrass (Aira caryophylla), large-headed sedge (Carex macrocephala), and sheep sorrel.

214. The southern half, dominated by grasses, was vegetatively heterogeneous. This upland grass-herb habitat was dominated by American dunegrass, red fescue, creeping bentgrass, and a variety of other grasses and herbaceous species.

Colonial nesting species

215. Four glaucous-winged gull and two common tern colonies were located on the northern half of the island. Another gull colony occurred on the southern half, and the northwest and southwest sand flats were heavily used loafing areas (Figure 37). Gull colonies were widely separated, although nesting within colonies was centralized. The total gull population for the island was estimated at 100 pairs.

216. On 9 June, 50 nests were observed to establish clutch characteristics. Twenty (40 percent) of the nests were empty. Of the active nests, 3 (10 percent) held one egg, 2 (7 percent) held two eggs, and 25 (83 percent) contained three eggs. The mean clutch size of the 30 nests containing eggs was 2.73 and 82 eggs were produced. The colony was small considering the amount of available breeding habitat.

217. Only seven pairs of common terns were observed nesting on the island in early June. Two nests were found in the sedge/bare ground and one in the velvetgrass/bare ground habitat types. All nests had three-egg clutches. When the colony was rechecked for success on 21 July, no evidence of nests or young was found.

Vegetation at the colony

218. Vegetation transects were established within the two largest colonies (Figure 37). Unidentified mosses were found throughout the northernmost colony and frequently covered much of the ground (Table 35). Rat-tail fescue (Festuca myuros), cheat grass, and silver hairgrass were the dominant vascular plant species and accounted for 60 percent of the cover. Five herb species were scattered throughout the site, but combined to account for only 12 percent ground cover.

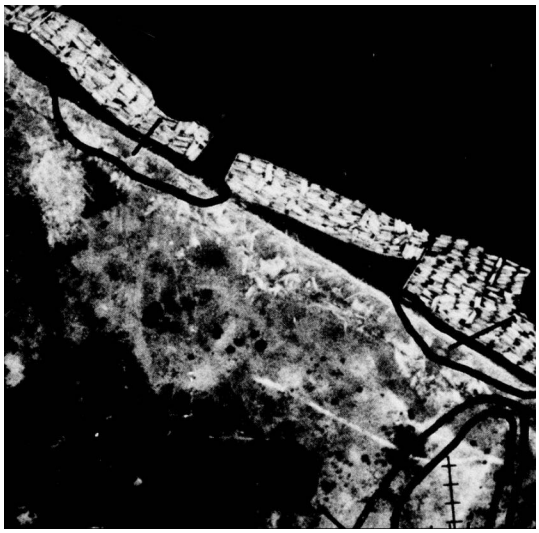
Table 35

North Gull Colony Vegetation of

Jetty Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Mosses	Unidentified species	--	30.5	0-100	50
Sedges	Large-headed sedge	--	0.3	0- 5	10
Grasses	Rat-tail fescue	80.6	23.8	2- 95	95
	Cheat grass	68.5	17.9	0- 75	90
	Silver hairgrass	44.4	17.5	0- 75	35
	American dunegrass	6.5	0.1	0- 5	15
	Tufted hairgrass	--	--	0-T	5
Herbs	Thistle	109.0	7.7	0- 35	70
	Tall peppergrass	52.7	2.9	0- 30	45
	Sheep sorrel	20.7	0.6	0- 5	25
	White clover	10.5	0.5	0- 10	10
	Fireweed	7.1	0.1	0- 2	10
Shrubs	Scotch broom	200.0	4.0	0- 50	20
Other	Bare ground	--	10.0	0- 40	50

* T: Trace

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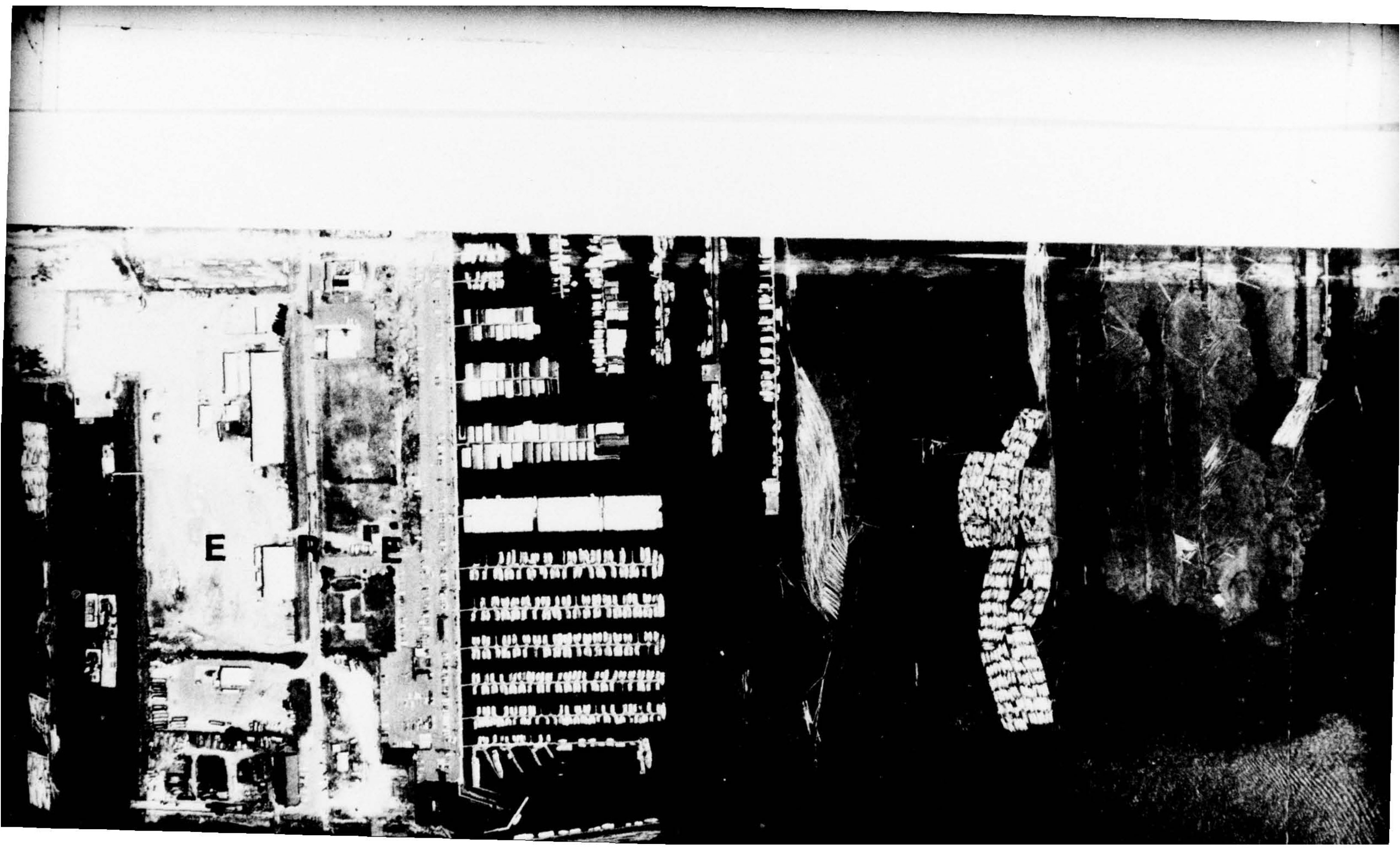
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219. The second transect was in the southern and second largest gull colony within dunegrass/log and dunegrass/sedge habitats (Tables 36 and 37). As in the northern colony, grasses accounted for most of the vegetation, especially bluegrass. Dunegrass was also prevalent and cheatgrass and red fescue were found only as trace species throughout the site. Herb species were more numerous, but still accounted for little of the total vegetation.

220. A variety of locations within the habitat types, often at the edge of vegetation clumps, logs, or debris, were used for nesting. Patches of dunegrass and other vegetation offered escape cover for nesting gulls.

221. Common terns were found nesting in two grass-herb habitat subtypes, velvetgrass/bare ground (north colony) and large-headed sedge/bare ground (south colony) (Table 38). Vegetation accounted for 9.7 percent cover in the north colony and 58.1 percent in the south colony. Species abundance was significantly lower in the tern colonies than in the gull colonies. Although the percent frequency of some species was high (100 percent for silver hairgrass and sedge, 65 percent for velvetgrass), the cover occupied by these species was low. Nests were exclusively located on gravel and bare sandy soil between sedge and grass patches.

Discussion

222. There are no published scientific accounts of the birds of Jetty Island. Consequently, little is known about the history of the gull colony before 1973, when Parks (1973) conducted a biological inventory of several dredged material sites in Everett. Common terns were observed feeding near the island, but there was no evidence of breeding. This is not surprising, since common terns are frequently observed as migrants through the Puget Sound region in the spring.

223. Gulls and terns utilized the upland portion of the island for nesting and the intertidal and sandy beach habitats for loafing and feeding. Migrant shorebirds, gulls, terns, and ducks all used the sand

Table 36

South Gull Colony Dunegrass/Log Vegetation of Jetty Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Mosses	Fern	200.0	2.7	0- 50	10
Grasses	Bluegrass	85.9	16.6	0- 80	80
	American dunegrass	82.3	14.5	0- 75	85
	Creeping bentgrass	19.4	2.6	0- 20	25
	Common velvetgrass	7.1	0.8	0- 15	10
	Rat-tail fescue	5.3	0.2	0- 5	10
	Silver hairgrass	--	--	0-T	5
Herbs	Thistle	135.9	0.9	0- 10	20
	Canadian thistle	39.7	0.3	0- 5	5
	Spotted cats-ear	24.4	0.1	0- 5	5
	Hawkweed	--	--	0-T	5
Other	Logs	--	63.0	0- 95	95

* T: Trace

Table 37

South Gull Colony Dunegrass/Sedge Vegetation of Jetty Island

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Mosses	Fern	200.0	9.0	0- 30	45
Grasses	American dunegrass	151.7	43.0	5- 90	100
	Silver hairgrass	41.2	6.0	0- 50	45
	Rat-tail fescue	7.1	0.3	0- 5	10
	Cheat grass	--	--	0-T	50
	Common velvetgrass	--	--	0-T	5
Sedges	Large-headed sedge	200.0	21.0	0- 80	50
Herbs	Field milk-thistle	86.9	7.0	0- 40	90
	Red clover	31.5	3.0	0- 20	25
	Sheep sorrel	35.2	2.0	0- 30	50
	Seashore lupine	15.5	1.0	0- 25	20
	Yarrow	9.8	0.5	0- 5	15
	Tall peppergrass	4.2	0.3	0- 5	5
	Hooker's evening-primrose	4.2	0.3	0- 5	5
	Beach pea	3.5	0.2	0- 3	5
	White clover	9.2	0.1	0- 2	20
	Fireweed	--	--	0-T	5
	Thistle	--	--	0-T	5
Other	Bare ground	--	6.0	0- 80	15
	Logs	--	0.8	0- 15	5

* T: Trace

Table 38

Common Tern Colony Vegetation of

Jetty Island

Life Form	Species	Importance Value	Percent Cover* Mean	Range	Percent Frequency
North Colony					
Grasses	Silver hairgrass	88.5	3.0	0- 10	100
	Common velvetgrass	76.5	3.6	0- 20	65
	American dunegrass	20.1	1.3	0- 15	10
	Creeping bentgrass	14.6	0.8	0- 10	10
	Rat-tail fescue	--	--	0-T	10
Herbs	Sheep sorrel	200.0	1.0	0- 5	30
	Tall peppergrass	--	--	0-T	5
Other	Bare ground	--	92.3	75-100	100
South Colony					
Grasses	Silver hairgrass	172.6	6.7	0- 25	100
	Rat-tail fescue	27.4	0.1	0- 5	35
	Creeping bentgrass	--	--	0-T	10
Sedges	Large-headed sedge	200.0	48.0	20-85	100
Herbs	Field milk-thistle	161.8	2.7	0- 20	60
	Sheep sorrel	22.4	0.3	0- 5	10
	Pearly-everlasting	15.8	0.3	0- 5	5
Other	Bare ground	--	36.0	0- 70	95
	Logs	--	1.5	0- 30	5

* T: Trace

flats for feeding and loafing. Migrant birds are probably the most important avian users of the island.

224. It seems likely that glaucous-winged gulls have occupied Jetty Island for many years. Because of occasional human disturbance, it probably provides only marginal nesting habitat for gulls. The breeding population that was observed may represent a surplus from higher quality nesting habitat available on islands of the nearby San Juan Archipelago and the Strait of Juan de Fuca.

225. The most significant ornithological observation on Jetty Island was the location of the common tern colony. This small colony represented the first breeding record for the State of Washington. Common terns are migrants frequently observed in the fall, but are unknown as a nesting species. The sudden appearance of this colony could have been due to the 1977 spring and summer drought which reduced breeding habitat for several species of waterfowl, shorebirds, and possibly terns in the northern midwest (personal communication, L. Oring 1977, Department of Biology, University of North Dakota). Common terns not finding suitable habitat in South Dakota and eastern Montana may have drifted westward to the coast. Also, terns from Asian populations have been sighted recently in the Aleutian Islands (personal communication, Paul Buckley 1977, U.S. National Park Service, Boston) and the birds on Jetty Island may be part of these populations which have dispersed southward.

226. Introduced mammals and human disturbance are the major environmental pressures that may reduce breeding success of the gull and tern colonies on Jetty Island. Norway rats (Rattus norvegicus) and microtine rodents (Sorex sp.) were observed on the island, but no carnivores have yet been seen. However, human visitors occasionally bring dogs, which probably harass and even kill nesting birds.

227. A more subtle adverse effect is the encroachment of herbaceous and shrub vegetation into nesting habitats through succession. Both gulls and terns on Jetty Island nested in open habitat types and,

if succession proceeds through the shrub stage, habitat for these species will be replaced with undesirable vegetation.

Padilla Bay Islands

Physical characteristics

228. The four Padilla Bay islands investigated resulted from hydraulic pipeline dredging of the Swinomish Channel (Figure 38), which was initiated in the 1890's and has continued to the present. The channel is an important transportation route for waterborne commerce between Skagit Bay on the south with Padilla Bay on the north. The present dredged channel replaces a natural slough that once connected the two bays.

229. Historically, the Skagit River formed the tidal flats of both Skagit and Padilla Bays. It now flows only into Skagit Bay and the Swinomish Channel provides the only route by which fresh water and silt from the Skagit enter Padilla Bay. Since river water first mixes with Skagit Bay marine waters before it enters the channel, the sediment transported to Padilla Bay is limited primarily to suspended silt.

230. The complex tidal fluctuations and topography have a dramatic effect on the shallow mud flats and dredged material islands. There is a general northward migration of sand along the channel bed. Aerial photographs show that the Padilla Bay islands were once more extensive than they were in 1977.

Habitat description

231. There were four recognizable islands at high tide along the west side of the Swinomish channel. All were similar with respect to their topography and existing habitats (Figure 39). In general, four habitat types were found among the islands: an intertidal sand flat and low marsh, and an upland dune and grass-herb meadow. The composition and relative density of vegetation within the major habitats are listed in Appendix A, Table A12. Sand flats extended around each island and formed shallow underwater connections between them; however, on the northernmost

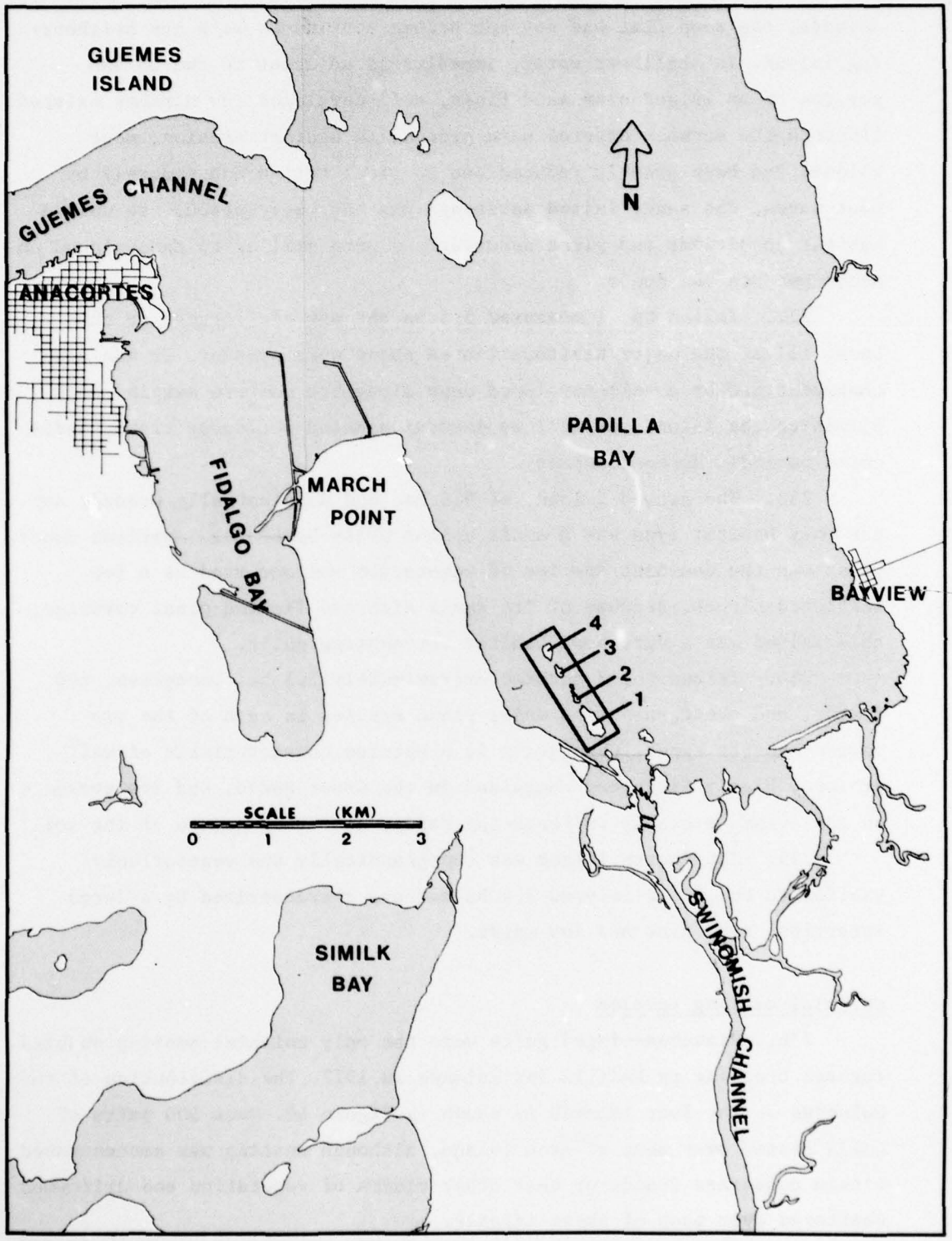


FIG.38 PADILLA BAY STUDY AREAS

islands, the sand flat had not yet become continuous with its neighboring island. In shallower water, immediately adjacent to the upland portion of an island near sand flats, well-developed low marshes existed. Although low marshes offered some protection against erosion, most islands had been greatly reduced due to tidal action and probably by boat waves. The sandy inland substrate was extremely porous, so upland habitat conditions and plant associations were similar to those found on ocean beaches and dunes.

232. Island No. 1 measured 5.5 ha and was the largest of the four. All of the major habitats listed above were present. It was also characterized by a well-developed dune along its eastern margin. Duck blinds on the island, as well as several planted deciduous trees, indicated periodic human occupancy.

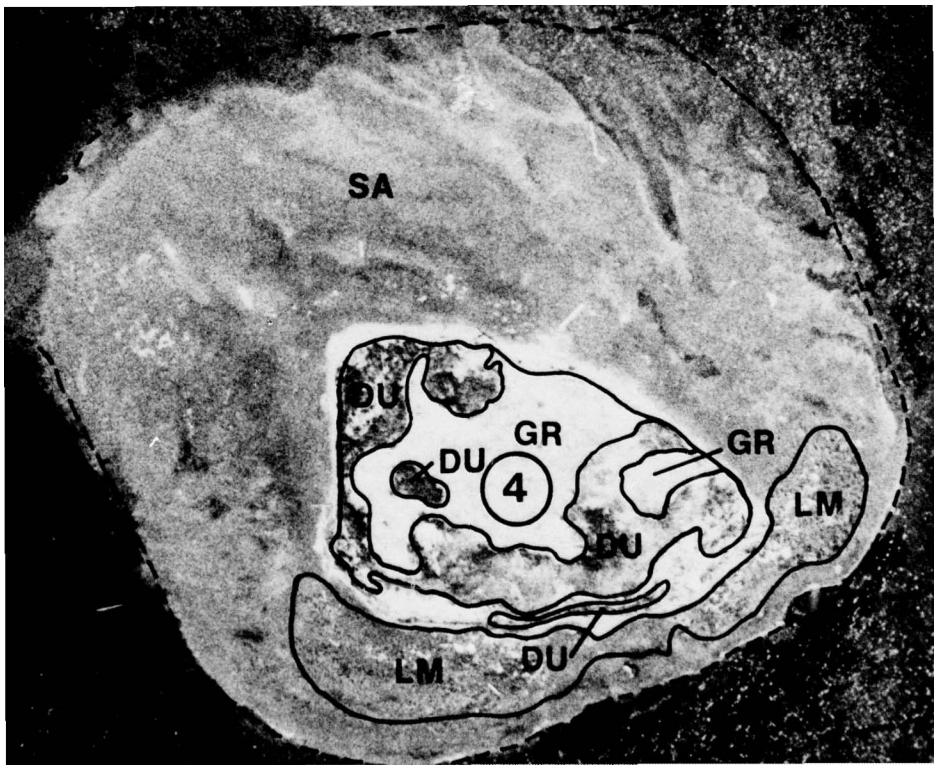
233. The second island, of 0.5 ha, had substantially eroded, and the only habitat type was a small upland grass-herb area. American dunegrass was the dominant species of vegetation and occurred as a few scattered plants. Because of its small size and limited plant coverage, this island was a very poor habitat for nesting gulls.

234. Island No. 3 covered approximately 3.1 ha. Dunegrass, red fescue, and cheatgrass were major plant species in each of the two upland habitat types. Cheatgrass is a species characteristic of well-drained, highly disturbed rangeland in the Great Basin, and its presence on the island probably reflects the sandy, disturbed nature of the soil.

235. The fourth island was topographically and vegetatively similar to No. 3. It covered 3.4 ha and was characterized by a large intertidal sand flat and low marsh.

Colonial nesting species

236. Glaucous-winged gulls were the only colonial nesting seabird species breeding on Padilla Bay islands in 1977. The distribution of the colonies on the four islands is shown in Figure 40. Over 500 pairs of gulls nested over most of each island, although nesting was concentrated within dunegrass stands or near other clumps of vegetation and driftwood scattered over much of these islands.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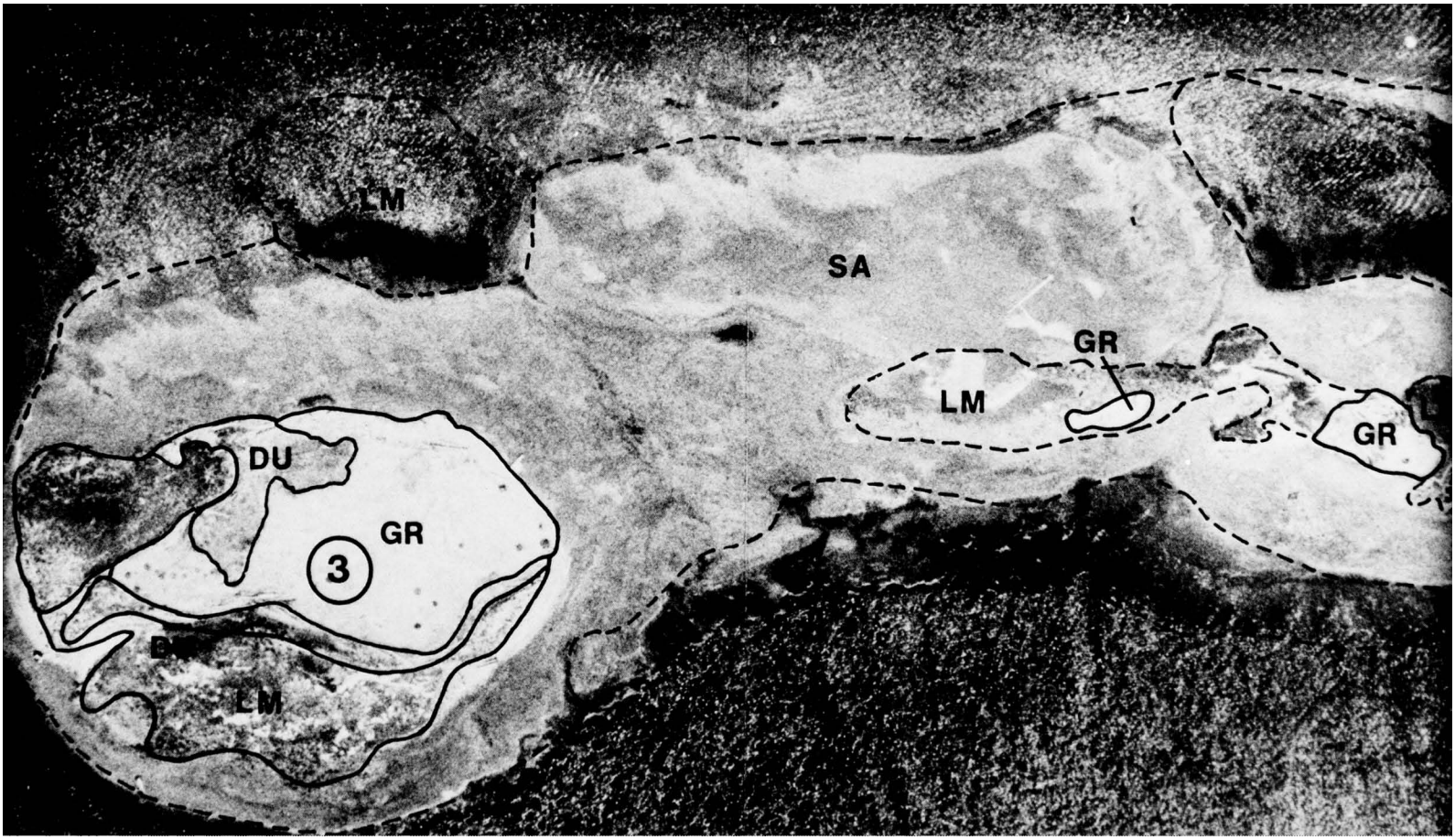
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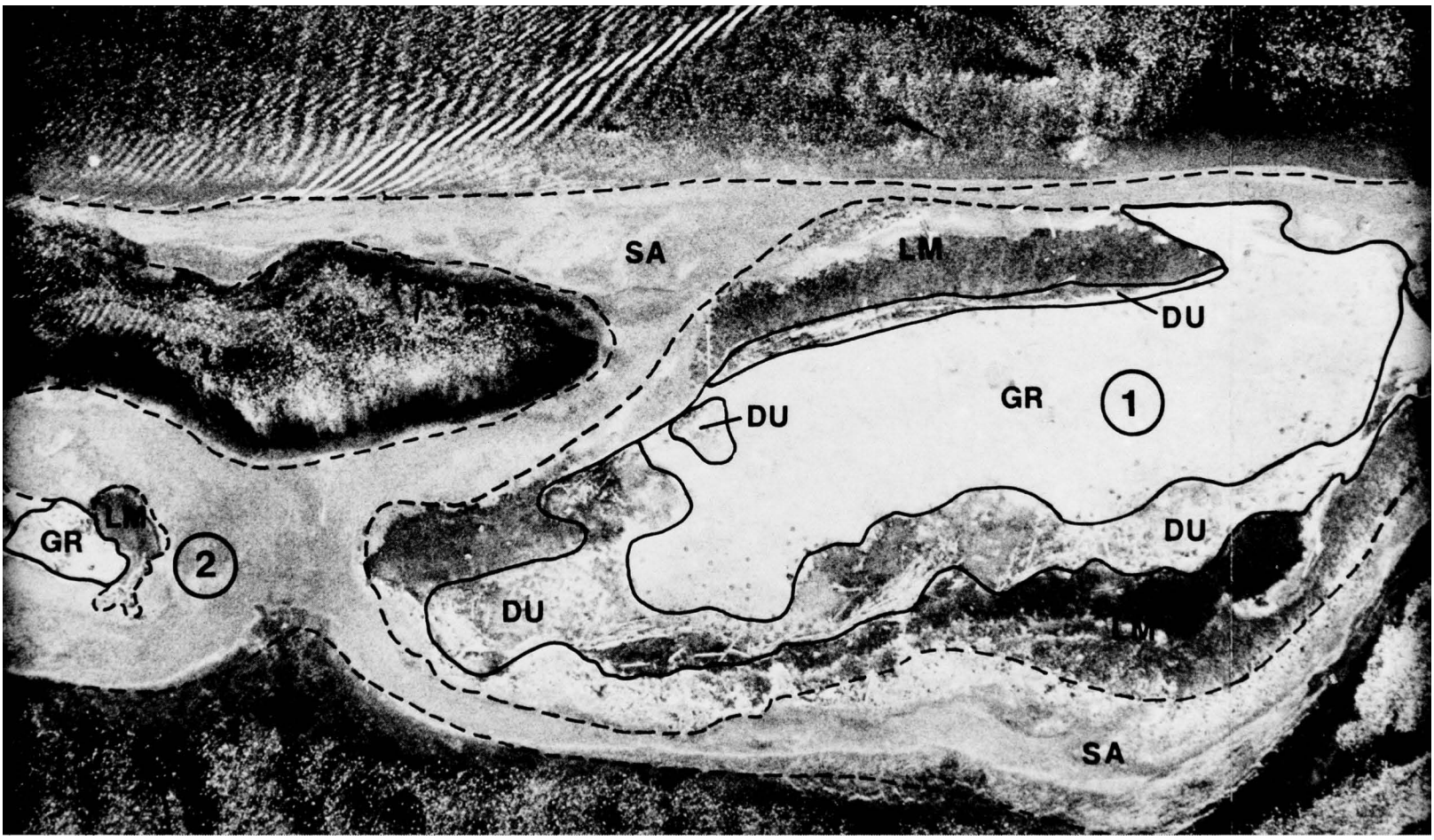
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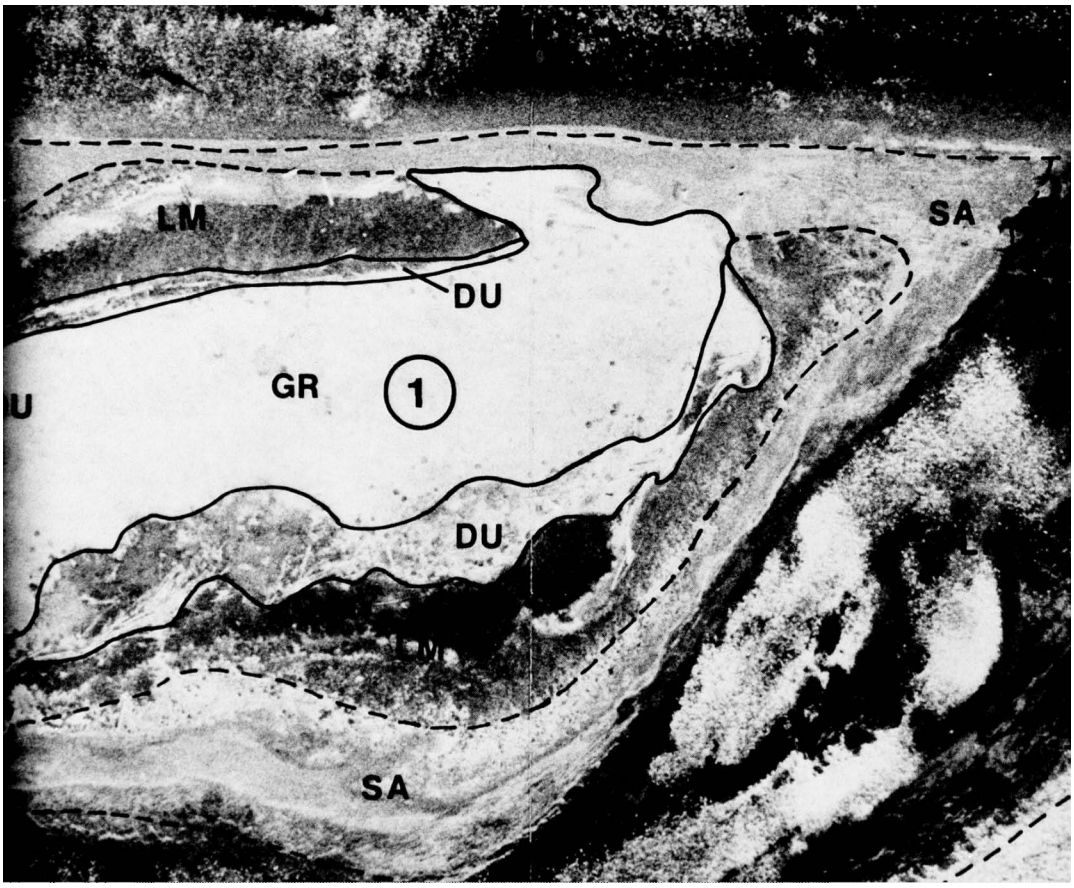
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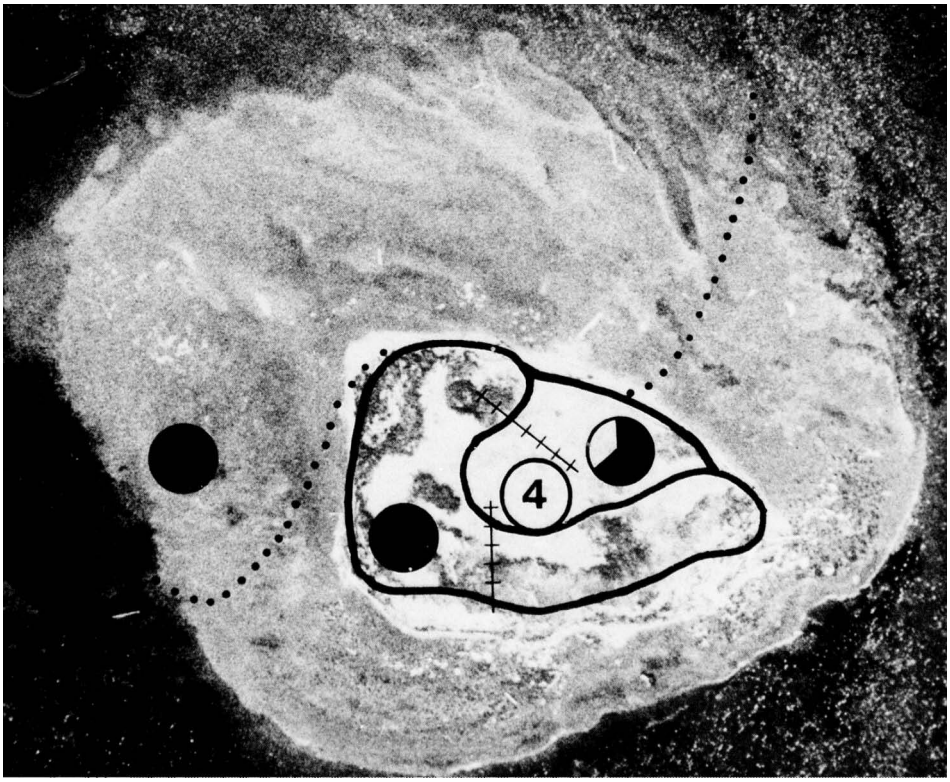
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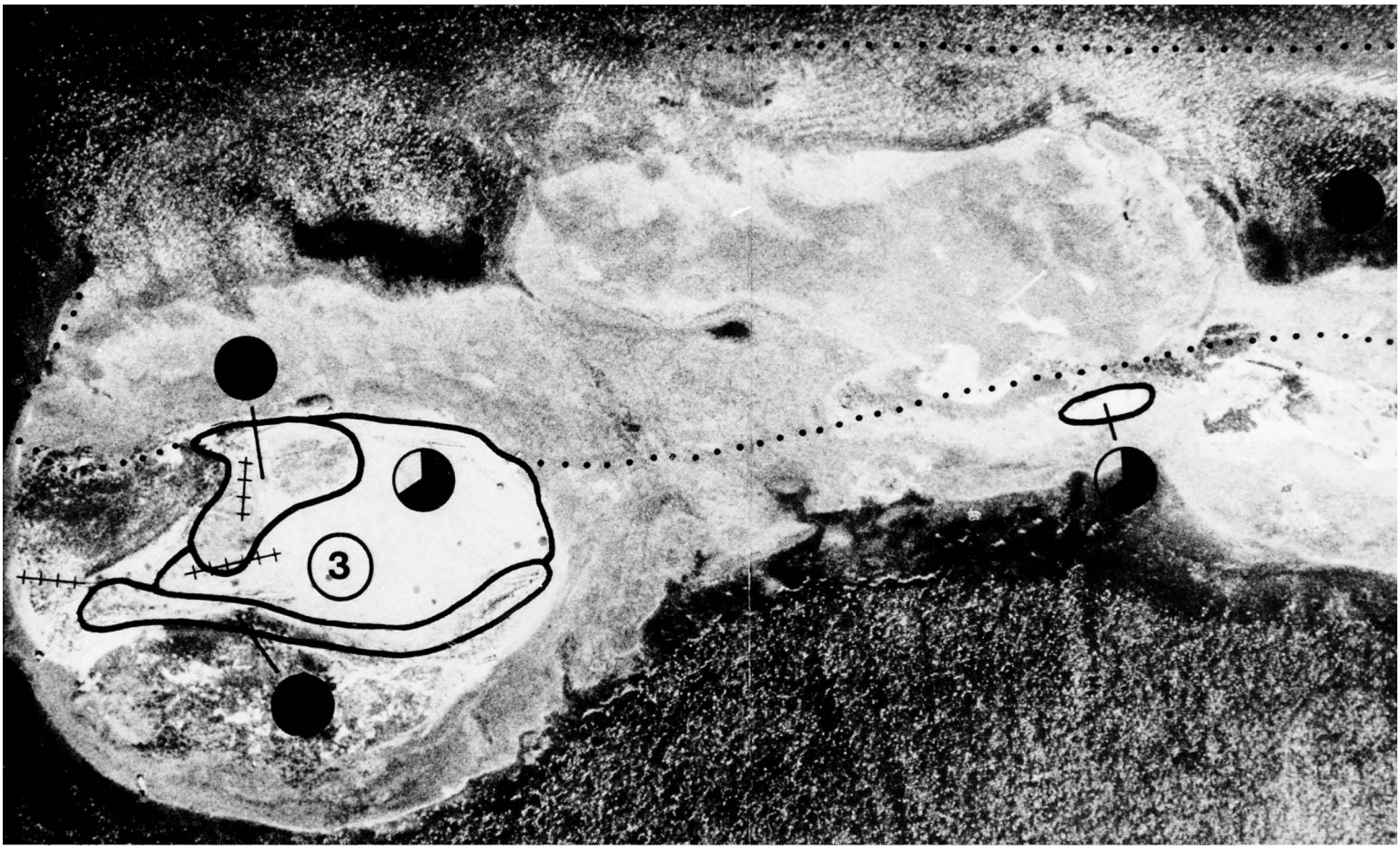
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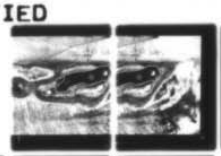

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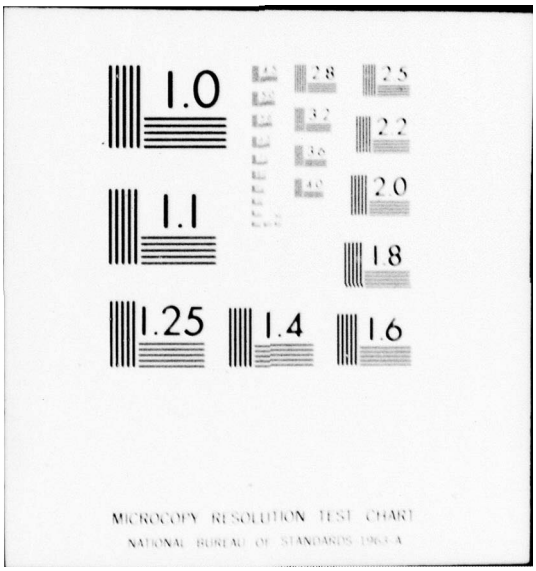
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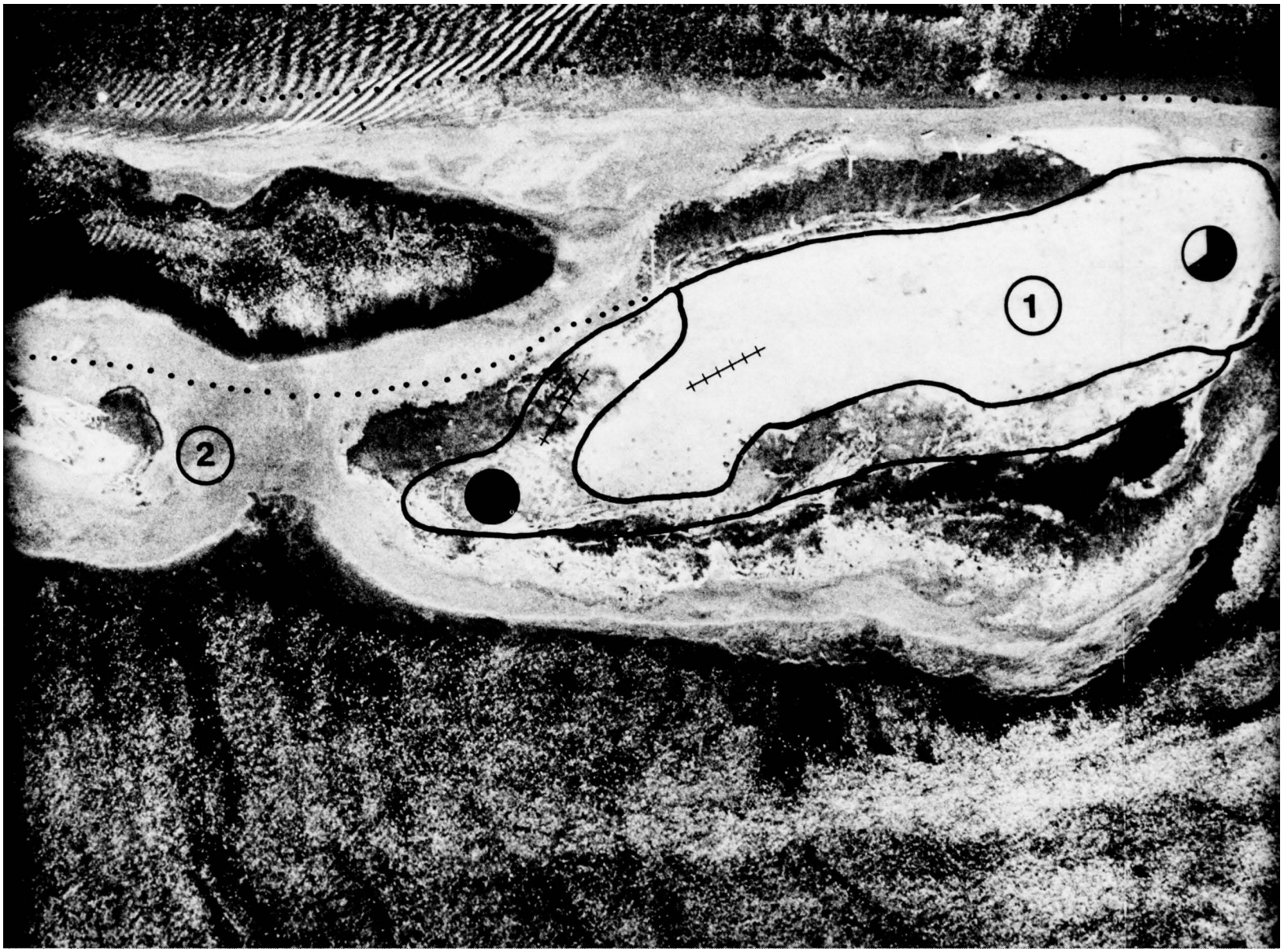
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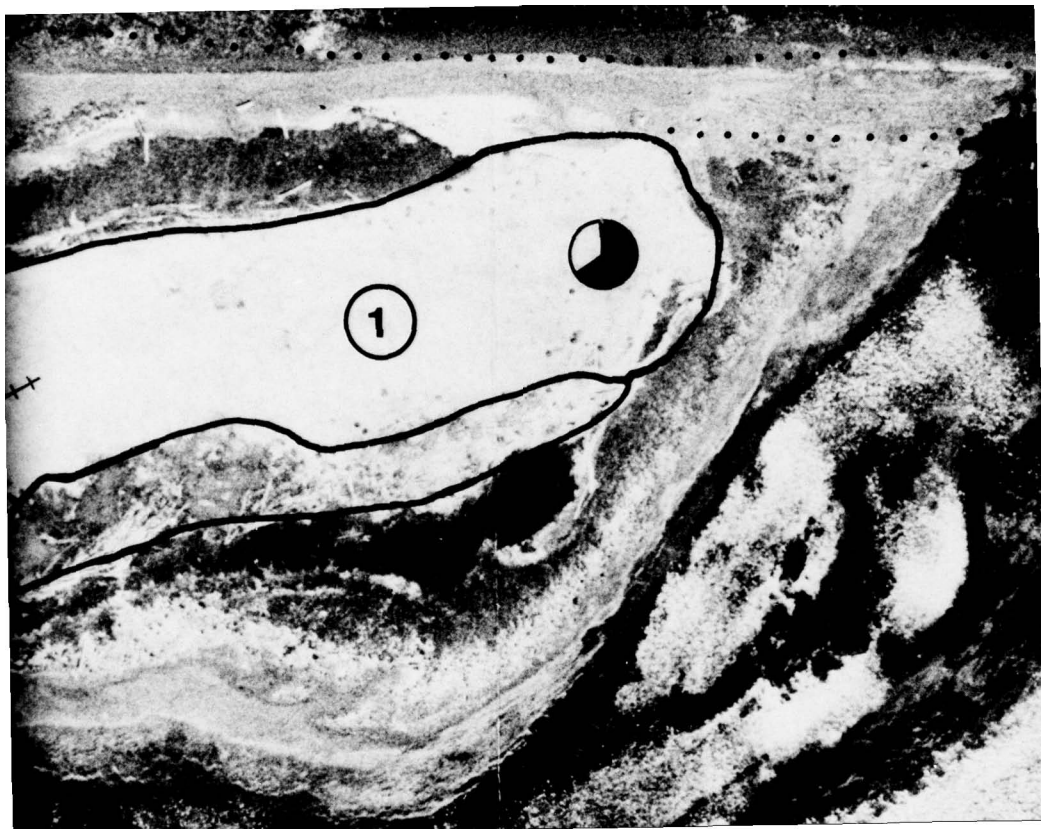
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237. The distribution of nests and clutch sizes for each island are summarized in Table 39. A total of 643 nests were found on the islands on 6 June, of which roughly 78 percent contained eggs. As expected, the largest island supported the greatest number of breeding birds. Nesting phenology and clutch size, however, did not differ significantly between islands. Mean clutch size for all nests was 2.73 and varied slightly.

238. Visits were not sufficiently frequent to observe egg-laying, incubation, hatching, and fledging phases. If it is assumed that 10 percent (50) of the active nests were two-egg clutches (see East Sand Island discussion), then by 6 June laying was completed in a total of 441 or 88 percent of the active nests. No chicks were observed in June, but by 18 July it was estimated that three fourths of all clutches had hatched. By 30 August, most gulls were fledged. The breeding phenology of the Padilla Bay islands was similar to that published by Drent et al. (1964) for the San Juan islands, 25 km to the west (Table 40).

Vegetation at the colony

239. Figure 40 shows the location of vegetation transects for each island surveyed. In general, plants in grass-herb and dune communities differed little in species composition, but varied significantly in abundance (Tables 41, 42, and 43). The grass-herb interior of the southernmost island (No. 1) was less vegetated than that of the central island (No. 3), which in turn was less vegetated than the northernmost island of the chain. Plant coverage within the grass-herb habitat of the three surveyed islands was 26, 52, and 79 percent for island Nos. 1, 2, and 3, respectively. Cheatgrass and rat-tail fescue dominated each grass-herb habitat. As suggested by Tables 41, 42, and 43, it appeared that, once cheatgrass had become established on an island, it outcompeted fescue and eventually dominated all grassland sites.

240. Several exotic herbs were scattered throughout the grasslands; however, they accounted for less than 7 percent of the total cover. Trampled unidentifiable grasses and herbs and bare sand covered the remainder of the grass-herb habitat.

Table 39

Gull Colony Nest Data on Padilla Bay Islands,

6 June 1977

Island	No. Nests	Percent With Eggs	Clutch Size of No. Nests 0	1	2	3	No. Eggs	Mean Clutch Size*
No. 1	261	80	52	10	27	172	580	2.78
No. 2	6	83	1	0	1	4	14	2.80
No. 3	144	69	44	5	19	76	271	2.71
No. 4	232	80	47	11	35	139	498	2.69
TOTAL			144	26	82	391	1363	

* Of active nests

Table 40

Breeding Phenology of Glaucous-Winged Gulls

Nesting Near Padilla Bay, Washington

	Pair Formation Date	Egg Laying Date	Incubation Date	Hatching Date	Fledging Date
Earliest *	March	15 May	30 May	27 June	16 Aug.
Latest *	April	12 July	25 July	21 Aug.	1 Oct.
This Study	--	6 June **	6 June +	18 July ++	30 Aug. +++

* Drent, et. al., 1964. Add two days for clutch completion.

** Complete in 88 percent of active nests.

+ Underway in 88 percent of active nests.

++ Approximately 3/4 complete.

+++ Most young fledged.

Table 41

Gull Colony Vegetation of Padilla Bay Island No. 1

Life Form	Species	Importance Value	Percent Cover Mean	Percent Cover Range	Percent Frequency
Grass-Herb Habitat					
Grasses	Cheat grass	97.4	10.0	0- 50	60
	Rat-tail fescue	84.6	9.0	0- 40	50
	Spike bentgrass	18.0	0.5	0- 5	20
Herbs	Common thistle	99.1	5.0	0- 30	20
	Unidentified composite	48.7	1.0	0- 5	30
	Thistle	52.1	0.5	0- 5	40
Other	Compressed vegetation	--	38.0	0- 75	80
	Bare ground	--	10.0	0- 30	60
Dune Habitat					
Grasses	American dunegrass	108.8	48.0	0- 80	100
	Spike bentgrass	54.5	14.5	0- 30	80
	Cheat grass	35.7	11.0	0- 40	50
Other	Bare ground	--	11.0	0- 40	70

Table 42

Gull Colony Vegetation of Padilla Bay

Island No. 3

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grass-Herb Habitat					
Grasses	Rat-tail fescue	111.4	27.5	0- 70	90
	Cheat grass	88.6	19.5	0- 55	80
	Common velvetgrass	--	--	0-T	100
Herbs	Common thistle	141.8	4.5	0- 15	60
	Birdsfoot-trefoil	58.2	1.0	0- 5	40
Other	Compressed vegetation	--	31.5	0- 60	90
	Bare ground	--	12.5	0- 40	60
Dune Habitat					
Grasses	American dunegrass	119.3	53.0	10-80	100
	Spike bentgrass	45.3	15.5	0- 60	50
	Cheat grass	35.4	8.0	0- 30	50
	Rat-tail fescue	--	--	0-T	100
Other	Bare ground	--	6.0	0- 10	70

* T: Trace

Table 43

Gull Colony Vegetation of Padilla Bay

Island No. 4

Life Form	Species	Importance Value	Percent Cover* Mean	Percent Cover* Range	Percent Frequency
Grass-Herb Habitat					
Grasses	Cheat grass	150.9	69.0	20-100	100
	Rat-tail fescue	49.1	9.0	0- 40	60
	American dunegrass	--	--	0-T	100
Herbs	Birdsfoot-trefoil	110.0	0.5	0- 5	50
	Thistle	90.0	0.4	0- 2	40
	Common thistle	--	--	0-T	40
	Unidentified composite	--	--	0-T	30
Other	Compressed vegetation	--	14.0	0- 70	30
	Bare ground	--	5.0	15-20	30
Dune Habitat					
Grasses	American dunegrass	100.6	61.0	10-100	100
	Spike bentgrass	47.9	28.0	0- 80	50
	Cheat grass	35.6	11.0	0- 60	60
	Rat-tail fescue	15.9	3.5	0- 20	30
Herbs	Common thistle	--	--	0-T	100
Other	Compressed vegetation	--	15.0	0- 50	60
	Bare ground	--	5.0	0- 10	40

* T: Trace

241. Dune vegetation density also increased from a low of 73 percent cover on the southern island to a high of 100 percent on the northern island. American dunegrass was the dominant species occurring in every quadrat of each transect and exhibited a mean average of 48, 53, and 61 percent on the southern, middle, and northern islands, respectively. Spike bentgrass (Agrostis exarata) and cheatgrass were two other important grasses found on dunes. Together, these species covered an average of 20 to 40 percent of sampled quadrats and both species were found in at least 50 percent of all plots. Rat-tail fescue was found in many quadrats, but the density was too low to account for any significant coverage.

242. Few herbs were observed on the dunes of these islands. An occasional thistle was observed on the more mature dune found on the northern island, but otherwise no herbs were observed. Unvegetated dune habitat was scattered throughout all islands, but never accounted for more than an average of 15 percent cover.

Discussion

243. There are no published accounts of the seabird colonies on the dredged material islands of Padilla Bay; therefore, conclusions on population changes over time cannot be made. However, gulls have been banded here for several years, and it is believed (personal communication, Terry Wahl 1977, Bellingham, Washington) that the population there has not changed since 1968, when banding was initiated.

244. These dredged material islands probably have been colonized by gulls originating from natural islands in the Puget Sound area. The breeding phenology and success of these colonies appeared to be similar to nearby colonies in the San Juan islands. In light of the large number of gulls already breeding on natural islands, the islands in Padilla Bay are not particularly valuable as nesting habitat. The islands could be used by postbreeding and migrant gulls, shorebirds, and waterfowl, but the importance of the islands to nonbreeding birds was not evaluated.

PART IV: DISCUSSION

Plant Community Structure and Successional Trends

245. On the islands studied, spatial and temporal characteristics of plant composition were observed which coincided with island location, topography, and history of human disturbance. Although successional progression was not quantified, trends in production, community structure, and homeostasis were apparent.

246. The physiognomic similarities of both dredged-material-influenced and natural islands were readily apparent, although species composition differed slightly. East Sand, Rennie, Half Moon, Jetty and the Padilla Bay islands had all been altered significantly by the construction of jetties and dikes and the deposition of dredged materials. However, the vegetation was similar to that observed for natural islands. Biomass, life form, and floristic structure were well stratified and clearly related to the physical parameters of the environment. In general, community structures were quite similar to those diagrammed in Figure 1.

247. In many respects, similarities were expected in light of the competitive capabilities of similar life forms and their adaptations to optimize the use of environmental resources. Dense low marshes, dominated by glasswort and seaside arrowgrass, were observed within the lower intertidal and sheltered sites of islands. High marshes of Lyngby's sedge, creeping bentgrass, and saltgrass occupied protected areas of intermediate elevation. Low marshes were best developed on islands such as Rennie Island within the lower reaches of estuaries, and high marshes were best developed on islands such as Fisher, Ryan, and Kellogg at the upper reaches of estuaries. Both marsh types were characterized by perennial ground cover which completely dominated the site.

248. The vegetation of beach, storm tide plain, dune, and upland habitats did not differ significantly on exposed islands. Beaches and storm tide plains were sparsely populated by American searocket, beach pea, giant vetch, yellow abronia, and other perennial herbs. Dunes were

stabilized and dominated by American dunegrass and European beach grass. Flat interior uplands were covered by grass meadows with a mixture of herbs. Driftwood hummocks, dikes, and other outcroppings were colonized by Scot's broom, furze, red elder, blackberry, and alder.

249. The progressive development of community differentiation, diversity, productivity, and relative stability generally increases with successional trends (Whittaker 1970). In this study area, the development of these characteristics depends on the extent of seasonal disturbance. The Willapa Bay islands and Sand, Goose, and Whitcomb islands in Grays Harbor are located close to the coast and harbor entrances and are greatly affected by wave action, tidal variation, blowing sand, and salt spray. Plant communities here are ephemeral, frequently succumbing to seasonal storms. Beaches, storm tide plains, dunes, and uplands are characterized by only a few herbs and grasses.

250. On more sheltered islands (East Sand, Jetty, and Padilla Bay), these habitats and their respective plant communities are confined to exposed lowland shore areas. Uplands exhibit stabilized dunes, well developed grass-herb meadows, and localized but expanding shrub communities. One of the most noticeable successional trends on most of the sheltered and more stable islands observed during this study was the rapid colonization, progressive expansion, and domination of nonnative vegetation. Included were creeping bentgrass, red fescue, common velvetgrass, and cheat grass. An annual species, cheat grass is especially well adapted to survival in the dry, disturbed areas abundant on these islands and may successfully colonize these areas in addition to displacing currently existing grasses and herbs. Observation of this species on Padilla Bay islands and East Sand Island in Baker Bay indicates that its present range encompasses all the islands.

251. Introduced herbs were found and included the Eurasian tansy and numerous composites. In general, herb-dominated communities were rare on the islands. Herbs were found on bare dunes, beaches, and driftwood sites, or else scattered among the grasses. The most rapidly expanding shrub on more stable islands was Scot's broom. This species is well adapted to survive in upland, sandy, well-drained soils characteristic

of both dredged and natural islands. Once introduced on an island, it rapidly dominates native grasses. No indigenous species and few introduced plants successfully codominate a site with Scot's broom for any significant time. On Jetty Island, the species appears to be slowly replacing the tenacious cheat grass on ridges and other uplands.

252. Furze, a spine-tipped European introduction structurally similar to Scot's broom, is widespread on West Sand Island in Baker Bay. It appears to have recently dispersed to East Sand Island, where it is found only as an occasional scattered bush. A rapid colonizer, furze may be expected to greatly increase its distribution on East Sand Island and may completely dominate better-drained upland habitats.

Distribution and Success of Gull Colonies

253. Gull nesting occurred in a wide variety of habitats, but was generally concentrated in driftwood scattered throughout grass-herb communities. East Sand Island best exhibited the range of nesting sites, primarily because of the diversity of existing habitats and pressure for their use. Gulls nested within beach, dune, grass-herb, grass-driftwood, driftwood hummock, and jetty habitats.

254. Difference in nesting success as measured by nest density, clutch size, or chick survival was not observed among these habitats, with the exception of the beach. Fewer nests were located here, and others were abandoned or covered with windblown sand. The storm tide line was observed inland from most nests and the number of nests decreased between successive weekly observations, indicating that high tides had flooded all beach nests. On Goose, Pine, and other islands where gulls nested on beaches, high tides may similarly have reduced nesting success.

255. Although plant composition varied between islands, driftwood was generally present in concentrated nesting areas, and it appeared that the distribution of wood rather than plant species was the primary factor affecting nest site preference. Although American dunegrass was commonly found, other species frequently dominated the preferred nesting

areas, including red fescue, rat-tail fescue, cheat grass, and creeping bentgrass (Table 44). Some islands supported very sparse vegetation (Gunpowder, Whitcomb) and Pine Island had no vegetation. Nesting here was concentrated near driftwood logs and success was believed to be low.

256. Table 45 summarizes the distribution and populations of breeding species observed during this study. No record was found of seabirds nesting on estuarine islands from Coos Bay, Oregon, to the Columbia River. Gulls observed south of Port Gardner Bay were classified as "western/glaucous-winged hybrids" based on varying morphology which precluded species identification. Gradations of coloring were observed which ranged from the pale gray mantle of the glaucous-winged gull to the dark back and wings of the western gull. As described by Peterson (1961), the mantle of the northern race of the western gull (Larus occidentalis occidentalis) is paler than that of the southern race. However, since very light and very dark individuals were observed nesting in the same colony, it appeared that individual species identification was not practical.

257. An idea of the proportions of the two species was obtained based on a preliminary classification of individuals as "dark," "medium," or "light" depending on mantle and wing tip pigmentation. A count of 237 adults at Goose Island resulted in a light to dark ratio of 1.7:1. In a similar count of adults at East Sand Island, the ratio was reversed and more than three dark birds were observed for every light one. It appears that the western gull may be strongly represented in colonies north to the Columbia River, but the range of this species is significantly overlapped by the glaucous-winged gull another 75 km further north. Additional studies of colonies along the Washington and Oregon coasts could further define the ranges of hybridization and provide information on the population composition and interspecific breeding activities of these species.

258. A summary of the breeding phenology of west coast gulls is shown in Table 46. Of the colonies observed in this study, hatching was initiated over a range of 1-1/2 weeks. It appeared that nesting began later in the north, although breeding activity occurred slightly earlier

Table 44

Plant Species Associated with Driftwood in Preferred Nesting Habitat of Gulls

Island	Plant Species
East Sand	Red fescue, dunegrass
Pine	None
Gunpowder	Very sparse dunegrass, searocket
Sand	Dunegrass, creeping bentgrass
Goose	Dunegrass
Whitcomb	Sparse dunegrass, searocket
Jetty	Dunegrass, rat-tail fescue, cheatgrass
Padilla Bay	Dunegrass

Table 45

Colonial Seabird Breeding Population Estimates of Pacific Northwest Estuarine Islands (From Coos Bay, Oregon to Padilla Bay, Washington)

Location	Species	Breeding Pairs
Coos Bay (9 islands)	None	
Columbia River Mouth (Baker Bay)		
East Sand Island	Western/glaucous-winged gull	1200*
Willapa Bay		
Pine Island	Western/glaucous-winged gull	80*
Gunpowder Island	Western/glaucous-winged gull	700-1200**
	Caspian tern	100**
Grays Harbor		
Rennie Island	None	
Half Moon Island	None	
Goose Island	Western/glaucous-winged gull	2500-3000*,**
Sand Island	Western/glaucous-winged gull	800-1000*,**
	Caspian tern	1700*
Whitcomb	Western/glaucous-winged gull	40*
	Caspian tern	300*
	Ring-billed gull	3-9*
Duwamish River		
Kellogg Island	None	
Port Gardner Bay		
Jetty Island	Glaucous-winged gull	100**
	Common tern	7*
Padilla Bay		
4 Islands Near Swinomish Channel	Glaucous-winged gull	500*
TOTALS:	Glaucous-winged gulls	600
	Western/glaucous-winged gulls	5320-6520
	Ring-billed gull	3-9
	Caspian tern	2100
	Common tern	7

* Count based on active nests
** Count based on census of adults

Table 46

Breeding Phenology of West Coast Gulls

Location	Projected Dates of Peak Activity		
	Laying*	Hatching**	Fledging+
This Study			
Padilla Bay	31 May+++	25 June++	6 Aug.
Jetty Island	31 May+++	25 June++	6 Aug.
Goose Island	20 May+++	16 June++	28 July
Sand Island	20 May+++	16 June++	28 July
East Sand Island	26 May+++	20 June++	1 Aug.
Other			
Southeast Alaska	10 June 72	4 July 72	
(Patten 1974)	24 May 73	20 June 73	
British Columbia		28 June 71	
(Hunt and Hunt 1976)		23 June 73	
California Channel Islands			
(Schreiber 1970)		6 June 68	
(Hunt and Hunt 1975)		29 May 72	

*50 percent of all active nests contained complete clutches.

**50 percent of all active nests contained at least one chick.

+Assuming 43-day nesting period (Schreiber 1970, Patten 1974).

++Projected based on clutch characteristics.

+++Assuming 26-day incubation period (Schreiber 1970, Patten 1974).

in Grays Harbor than at the Columbia River, to the south. Egg-laying, hatching, and fledging dates projected for this study were based on limited field observation and therefore are only approximations. Nevertheless, data from other areas of the west coast show that a seasonal nesting gradient occurs from California to southeast Alaska. The dates reported for this study are consistent with the published data since hatching generally occurred between dates reported for California and British Columbia.

Distribution and Success of Caspian Tern Colonies

259. Smith and Mudd (1976) observed Caspian terns and gulls competing for nesting space on the well-vegetated dunes of Goose Island. In this study, however, Caspian terns were observed nesting only on sparsely vegetated sandy beaches and storm tide plains. It therefore appeared that habitat requirements of Caspian terns were rather specific when compared to those of gulls.

260. The limitations imposed by population pressure, available habitat, and interspecific competition with gulls generally determine the size and location of tern colonies. All islands in this study were limiting in at least one of these factors. Beach and storm tide plains, the preferred nesting habitat, were absent on Rennie and Kellogg islands, and occupied only a small portion of East Sand, Jetty, Goose, and the Padilla Bay islands. In Willapa Bay, all islands had extensive nonvegetated sand habitats, but storms, high tides, accretion, and erosion prevented the consistent availability of habitat in any one location.

261. Historical data and field observations for Grays Harbor and Willapa Bay indicate that Caspian terns frequently alter colony location. The declining population of Goose Island occurred during a simultaneous increase in the Whitcomb and Sand island colonies (Smith and Mudd 1976, Penland 1976b). Colonies also appear to have shifted between Pine and Gunpowder islands in Willapa Bay. Goose Island tern habitat was apparently severely reduced by several winter storms, but there appears to be no clear reason for the shift between islands in Willapa Bay. In 1977,

Whaleback Island, just north of Gunpowder, had a large expanse of dry sand throughout the breeding season, yet was not colonized.

262. It has been suggested that the destruction of habitat in California and eastern Washington may have resulted in an increasing number of terns breeding on these Washington coastal islands. Other sources suggest that tern colonies have been located here at least since the early 1900's. Additional factors affecting colony location could include food availability, competition with expanding western/glaucous-winged gull populations, and annual changes resulting from accretion and erosion of existing habitats due to winter storms and seasonal tides.

263. Tern breeding phenology of Grays Harbor islands appeared consistent with that reported by Penland (1976a). Peak egg-laying occurred around 20 May, although nests with eggs were found throughout the nesting season as late as mid-August. Hatching began approximately 22 May, and peaked near 14 June. The timing of this cycle was roughly 2 weeks earlier than that of the western/glaucous-winged gull observed in this area. The nesting efforts which occurred throughout the season probably were attempts by birds which were unsuccessful earlier in the year. It appeared that nesting areas in Grays Harbor were not disturbed by high water and the renesting efforts may have been from birds displaced from Gunpowder Island in Willapa Bay.

Distribution and Success of Heron Colonies

264. Aerial searches of the lower Columbia from River Mile 32 to 60 revealed heronries only on Fisher and Ryan islands. Fisher Island contains one of the largest colonies in Washington. The Ryan Island heronry has not been previously investigated, although it appeared to be much larger than earlier reports indicated.

265. Several studies have documented the distribution and reproductive ecology of herons in Oregon. Werschkul et al. (1977) found 12 heronries of 15 to 175 nests along the Oregon coast. Fledged young per nest ranged from 2.18 to 2.70 and were significantly related to active number of nests per ha and average number of nests per tree. Karlson

Island, at River Mile 26 of the lower Columbia, contained a 175-nest heronry where productivity was estimated at 475 fledged young annually. Scott English (personal communication 1977, Wildlife Biologist, U.S. Fish and Wildlife Service, Portland Oregon) recently surveyed 31 heronries along the Willamette River. The number of active nests per colony was significantly smaller than those observed along the coast, due to the smaller number of available nesting trees. Active nests ranged from 2 to 54, the largest number of nests being observed in the tallest and largest diameter trees. Nesting success for seven representative colonies varied between 2.17 and 2.71 fledged birds per nest.

266. Heron colony distribution and productivity in western Washington has not been well documented. Herons are commonly observed from the lower Columbia River to the Canadian border, which suggests that a viable population is maintained. The colonies observed during this study appeared to be successful and the potential for expansion of the Ryan Island population appeared good. Both colonies were well isolated from human disturbance, had an adequate number of nesting trees, and appeared to have adequate food supplies nearby. Recent and planned deposition of dredged material adjacent to Fisher Island will eliminate a large shallow area which may represent an important feeding area for the birds. Accessibility to the colony may also be improved, which could result in desertion of the nesting site.

Mammalian Species

267. Few mammals were observed during bird and vegetation studies. Nutria (Myocastor coypus) were abundant on East Sand Island and Norway rats were common on Jetty Island. Harbor seals were observed during aerial flights and field visits to Willapa Bay and Grays Harbor. They were most frequently observed on sand bars that had been exposed at low tide. Because seals feed on fish, mollusks, and crustaceans, they do not pose a threat to colonial nesting seabirds in this region.

268. The destruction of insular flora and fauna by introduced mammals is well documented (Holgate and Wace 1961). On estuarine islands,

nutria and Norway rats are foremost among destructive introduced pests. Nutria were abundant on East Sand Island and within the borders of the gull colony. Trails and feces were detected throughout all vegetated habitats and individuals were observed foraging during the day. These muskrat-like rodents are semiaquatic herbivores, first introduced into western Oregon in the late 1930's (Presnell 1958).

269. The density and effects of nutria on East Sand Island do not appear to have significantly influenced the structure or composition of plant communities. Cursory observations indicated that herbaceous plants rather than grasses were consumed. Therefore, grasses, the dominant plant component of the gull colony, are presently unaffected by nutria grazing. Nevertheless, nutria are serious pests known for their voracious appetites and their habit of digging large burrows in dikes, banks, and other structures (Ingles 1965). High population densities could result in dispersal of nutria throughout the gull colony, and in increased disruption of breeding activities and nesting habitat.

270. Norway rats were observed only on Jetty Island where they occurred throughout most habitats. This rodent probably feeds heavily on grasses and other vegetation, and during the summer may prey on gull and tern eggs of unattended nests.

PART V: MANAGEMENT RECOMMENDATIONS

271. The results of this study and a historical review of colony location, size, and production indicate that gull and tern populations are expanding and dispersing in the Pacific Northwest. Presently, habitat formed from dredged material provides nesting areas of marginal importance to the total population. Therefore, island stabilization, vegetation, and other habitat enhancement techniques are unnecessary in light of the current availability of nesting habitat. However, existing nesting areas should be maintained and monitored; detrimental effects can be minimized by the strategic location of dredged material rather than by outright management schemes. This recommendation should be reviewed in the future as development of the relatively unpopulated area increases. As natural habitat diminishes, increased importance will be placed on artificially maintained habitat for species preservation.

272. The status of the heron population in this area is uncertain. Habitat in the Columbia River basin appears adequate, but development constantly encroaches on natural areas required by this species. It is recommended that additional studies be undertaken to determine the population status and relative importance of colonies in the lower Columbia estuary. Management specifically for the enhancement of this species is not recommended at this time.

273. Many islands observed during this study exhibited valuable characteristics for roosting, feeding, and postbreeding waterfowl and shorebirds. The shallow intertidal sand and mud flats characteristic of dredged material islands are perhaps the most important feeding areas for these species in this area.

274. This study demonstrated the importance of a continuous inventory of existing bird populations, especially in the physically and biologically dynamic estuaries of the Pacific Northwest coast. Continued investigations of the distribution and abundance of waterbirds are recommended. Since habitat characteristics have been shown to cause rapid and major shifts in tern and gull colony locations. Predation, food supply, and human disturbance also play an important role in

seabird productivity, and an analysis of all factors is required to effectively manage habitat for the maintenance and enhancement of these species.

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APPENDIX A: ISLAND VEGETATION COMPOSITION AND RELATIVE DENSITY BY HABITAT TYPE AND LIFE FORM

Relative Densities Subjectively Evaluated
Based on Field Observation

A = Abundant

C = Common

U = Uncommon

Table A1

Vegetation Composition and Relative Density on Fisher Island

Habitat Type	Life Form	Species	Relative Density
High Marsh	Sedges	Carex lyngbyei	A
	Herbs	Impatiens noli-tangere	C
Grass-Herb	Grass	Dactylis glomerata	C
		Holcus lanatus	C
	Herbs	Urtica dioica	U
	Shrubs	Rubus discolor	U
		Rubus leucodermis	U
	Trees	Populus trichocarpa	U
Shrub	Herbs	Urtica dioica	U
		Salix sp.	A
		Salix scouleriana	A
		Alnus rubra	A
		Salix hookeriana	C
		Salix lasiandra	C
		Cornus nuttallii	C
	Shrubs	Rubus leucodermis	U
		Rosa gymnocarpa	U
Forest	Herbs	Urtica dioica	A
		Galium sp.	U
	Shrubs	Rubus leucodermis	C
		Sambucus racemosa	U
	Trees	Populus trichocarpa	A
		Fraxinus latifolia	U
		Cornus nuttallii	U
		Alnus rubra	U

Table A2

Vegetation Composition and Relative Density on Ryan Island

Habitat Type	Life Form	Species	Relative Density
Low/High Marsh	Sedges	Carex lyngbyei	A
	Herbs	Typha latifolia	C
		Iris pseudacorus	C
		Habenaria dilatata	C
Shrub	Sedges	Carex lyngbyei	U
	Shrubs	Salix sp.	A
		Salix scouleriana	A
		Alnus rubra	C
		Cornus nuttallii	C
		Rubus spectabilis	U
Forest	Sedges	Carex lyngbyei	U
	Herbs	Oenanthe sarmentosa	C
		Lysichitum americanum	U
		Impatiens noli-tangere	U
		Aster sp.	U
		Typha latifolia	U
	Shrubs	Rubus spectabilis	A
		Rubus leucodermis	C
		Symphoricarpos albus	C
		Rosa sp.	U
		Ribes lacustre	U
		Physocarpus capitatus	U
		Viburnum edule	U
	Trees	Populus trichocarpa	A
		Picea sitchensis	U
		Cornus nuttallii	U
		Fraxinus latifolia	U

Table A3

Vegetation Composition and Relative Density

on East Sand Island, Baker Bay

Habitat Type	Life Form	Species	Relative Density
Beach	Grasses	Elymus mollis	U
	Herbs	Abronia latifolia	U
		Cakile edentula	U
Storm Tide Plain	Grasses	Elymus mollis	U
	Herbs	Cakile edentula	U
		Lupinus littoralis	U
		Abronia latifolia	U
Dune	Grasses	Elymus mollis	A
		Festuca rubra	C
		Deschampsia caespitosa	C
		Agrostis alba	C
		Holcus lanatus	C
		Bromus secalinus	C
		Poa sp.	U
	Herbs	Lathyrus japonicus	C
		Gnaphalium purpureum	C
		Cardionema ramosissimum	C
		Cakile edentula	U
		Lupinus littoralis	U
		Convolvulus soldanella	U
		Polygonum paronychia	U
		Agoseris heterophylla	U
		Plantago lanceolata	U
		Abronia latifolia	U

(Continued)

Table A3 (Continued)

Habitat Type	Life Form	Species	Relative Density
Driftwood Hummock	Grasses	Holcus lanatus	U
	Ferns	Polystichum munitum	U
	Herbs	Cirsium arvense	C
		Tanacetum vulgare	C
		Scrophularia californica	C
		Conioselinum pacificum	C
		Achillea millefolium	C
		Agoseris heterophylla	C
		Vicia gigantea	C
		Senecio sp.	C
		Sonchus arvensis	U
		Solidago sp.	U
	Shrubs	Ulex europaeus	C
		Sambucus racemosa var. arborescens	C
		Cytisus scoparius	U
		Lonicera involucrata	U
Grass-Herb	Grasses	Agrostis alba	A
		Deschampsia caespitosa	A
		Festuca rubra	A
		Holcus lanatus	A
		Bromus mollis	U
		Bromus tectorum	U
		Poa sp.	U
	Herbs	Cardionema ramosissimum	A
		Tanacetum vulgare	C
		Plantago lanceolata	C
		Polygonum paronychia	C

(Continued)

Table A3 (Concluded)

Habitat Type	Life Form	Species	Relative Density
		Anaphalis margaritacea	C
		Potentilla pacifica	C
		Rumex acetosella	C
		Convolvulus soldanella	U
		Cirsium arvense	U
		Fragaria chiloensis	U
	Trees	Picea sitchensis	U
Forest	Grasses	Festuca rubra	A
	Herbs	Achillea millefolium	U
	Trees	Picea sitchensis	C
Jetty	Herbs	Vicia gigantea	C
		Scrophularia californica	U
Low Marsh	Grasses	Agrostis alba	C
		Agropyron intermedium	U
	Rushes	Juncus balticus	A
	Sedges	Carex lyngbyei	A
	Herbs	Salicornia virginica	A
		Triglochin maritima	A
		Atriplex patula	C

Table A4

Vegetation Composition and Relative Density

on Gunpowder Island

Habitat Type	Life Form	Species	Relative Density
Storm Tide Plain	Grasses	Elymus mollis	U
	Herbs	Cakile edentula	C
Grass-Herb	Grasses	Elymus mollis	A
		Ammophila arenaria	U
	Herbs	Cakile edentula	A
		Honkenya peploides	U

Table A5

Vegetation Composition and Relative Density on Rennie Island

Habitat Type	Life Form	Species	Relative Density
Mud Flat	Sedges	Carex lyngbyei	U
		Scirpus americanus	U
	Herbs	Salicornia virginica	C
		Cotula coronopifolia	C
		Triglochin maritima	C
Low Marsh	Grasses	Agrostis alba	C
		Deschampsia cespitosa	U
	Sedges	Carex lyngbyei	A
		Scirpus americanus	A
	Herbs	Atriplex patula	C
		Salicornia virginica	C
		Cotula coronopifolia	C
		Triglochin maritima	C
		Potentilla pacifica	U
High Marsh	Grasses	Agrostis alba	A
		Deschampsia caespitosa	A
		Polypogon monspeliensis	C
		Hordeum brachyantherum	U
	Rushes	Juncus balticus	U
	Herbs	Potentilla pacifica	C
		Trifolium repens	C
		Aster subspicatus	C
		Epilobium watsonii	U
		Sonchus oleraceus	U

(Continued)

Table A5 (Concluded)

Habitat Type	Life Form	Species	Relative Density
		Typha latifolia	U
	Shrubs	Alnus rubra	U
		Gaultheria shallon	U
		Sambucus racemosa	U
Storm Tide Plain	Herbs	Cakile edentula	U
Dike	Grasses	Holcus lanatus	A
		Deschampsia caespitosa	C
		Phalaris arundinacea	C
		Agrostis alba	U
	Herbs	Cirsium vulgare	A
		Equisetum arvense	C
		Lotus corniculatus	C
		Trifolium repens	C
		Achillea millefolium	C
		Cirsium arvense	C
		Senecio vulgaris	C
		Rumex crispus	U
		Spergularia canadensis	U
		Aster subspicatus	U
		Sonchus oleraceus	U
Freshwater Marsh	Herbs	Typha latifolia	A
Forest	Sedges	Carex sp.	C
	Herbs	Galium trifidum	U
	Shrubs	Galtheria shallon	C
	Trees	Alnus rubra	A

Table A6

Vegetation Composition and Relative Density

on Half Moon Island

Habitat Type	Life Form	Species	Relative Density
Sand Flat	Herbs	Salicornia virginica	U
		Cakile edentula	U
Storm Tide Plain	Grasses	Agrostis alba	C
		Elymus mollis	U
	Rushes	Juncus sp.	U
	Sedges	Carex lyngbyei	U
		Eleocharis palustris	U
		Scirpus americanus	U
	Herbs	Cakile edentula	A
		Rumex persicarioides	C
		Atriplex patula	C
		Salicornia virginica	C
		Cotula coronopifolia	C
		Honkenya peploides	U
		Spergularia canadensis	U
		Potentilla pacifica	U
		Triglochin maritima	U
Grass-Herb	Grasses	Agrostis alba	A
		Deschampsia caespitosa	C
		Elymus mollis	C
		Agropyron repens	U
		Holcus lanatus	U
		Hordeum brachyantherum	U
		Polypogon monspeliensis	U

(Continued)

Table A6 (Concluded)

Habitat Type	Life Form	Species	Relative Density
	Sedges	Carex lyngbyei	U
		Scirpus americanus	U
	Herbs	Rumex persicarioides	C
		Potentilla pacifica	C
		Lathyrus japonicus	C
		Lotus corniculatus	C
		Rumex acetosella	U
		Rumex crispus	U
		Rumex salicifolius	U
		Atriplex patula	U
		Spergularia canadensis	U
		Cakile edentula	U
		Vicia gigantea	U
		Galium sp.	U
		Cotula coronopifolia	U
		Senecio vulgaris	U
	Shrubs	Salix hookeriana	U

Table A7

Vegetation Composition and Relative Density on Sand Island

Habitat Type	Life Form	Species	Relative Density
Beach	Grasses	Elymus mollis	U
	Herbs	Cakile edentula	C
Dune	Grasses	Ammophila arenaria	A
		Elymus mollis	C
		Holcus lanatus	C
		Phragmites australis	U
	Herbs	Tanacetum douglasii	C
		Cakile edentula	U
		Lathyrus japonicus	U
		Achillea millefolium	U
		Hypochaeris radicata	U
		Senecio vulgaris	U
Driftwood-Grass	Grasses	Elymus mollis	A
		Holcus lanatus	A
		Agrostis alba	U
	Herbs	Lathyrus japonicus	C
		Vicia gigantea	C
		Angelica lucida	U
		Convolvulus sepium	U
		Galium aparine	U
		Sonchus oleraceus	U
	Shrubs	Rubus laciniatus	U
Grass-Herb	Grasses	Elymus mollis	A

(Continued)

Table A7 (Concluded)

Habitat Type	Life Form	Species	Relative Density
		Holcus lanatus	A
		Deschampsia caespitosa	U
		Festuca myuros	U
		Festuca rubra	U
	Herbs	Lathyrus japonicus	C
		Angelica lucida	C
		Hypochaeris radicata	C
		Rumex salicifolius	U
		Fragaria virginiana	U
		Potentilla pacifica	U
		Vicia gigantea	U
		Heracleum lanatum	U
		Galium aparine	U
		Achillea millefolium	U
		Senecio vulgaris	U
	Shrubs	Salix hookeriana	U
		Physocarpus capitatus	U
		Rubus spectabilis	U
Grass/Herb/ Hummock	Grasses	Elymus mollis	A
	Herbs	Cakile edentula	A
Grass Hummock	Grasses	Elymus mollis	A
		Ammophila arenaria	U
	Herbs	Cakile edentula	U

Table A8

Vegetation Composition and Relative Density

on Goose Island

Habitat Type	Life Form	Species	Relative Density
Beach	Herbs	Cakile edentula	C
		Honkenya peploides	U
Storm Tide Plain	Grasses	Agrostis alba	C
		Elymus mollis	C
		Distichlis spicata	U
	Herbs	Atriplex patula	C
		Salicornia virginica	C
		Cakile edentula	C
		Potentilla pacifica	U
		Senecio vulgaris	U
Dune	Grasses	Ammophila arenaria	A
		Elymus mollis	C
		Holcus lanatus	U
	Herbs	Ambrosia chamissonis	C
		Tanacetum douglasii	C
		Rumex acetosella	U
		Lathyrus japonicus	U
		Achillea millefolium	U
		Senecio vulgaris	U
		Sonchus oleraceus	U
	Shrubs	Picea sitchensis	U
Grass-Herb	Grasses	Elymus mollis	A
		Holcus lanatus	A

(Continued)

Table A8 (Concluded)

Habitat Type	Life Form	Species	Relative Density
		Agrostis alba	C
		Agropyron repens	U
		Ammophila arenaria	U
		Deschampsia caespitosa	U
		Hordeum brachyantherum	U
	Herbs	Lathyrus japonicus	C
		Rumex acetosella	U
		Vicia gigantea	U
		Angelica lucida	U
		Oenanthe sarmentosa	U
		Galium trifidum	U
		Ambrosia chamissonis	U
		Hypochaeris radicata	U
		Senecio vulgaris	U
		Sonchus oleraceus	U

Table A9

Vegetation Composition and Relative Density

on Whitcomb Island

Habitat Type	Life Form	Species	Relative Density
Storm Tide Plain	Herbs	Cakile edentula	U
Dune	Grasses	Elymus mollis	C
		Ammophila arenaria	U
	Herbs	Cakile edentula	A
		Honkenya peploides	U

Table A10

Vegetation Composition and Relative Density of Kellogg Island

Habitat Type	Life Form	Species	Relative Density
Low Marsh	Grasses	Agrostis alba	U
	Sedges	Carex lyngybei	U
	Herbs	Atriplex patula	C
		Cotula coronopifolia	C
		Spergula sp.	U
High Marsh (Estuarine)	Grasses	Distichlis spicata	A
		Agrostis alba	C
	Rushes	Juncus balticus	U
	Sedges	Carex lyngbyei	A
	Herbs	Potentilla pacifica	C
		Atriplex patula	U
High Marsh (Brackish)	Grasses	Agrostis alba	A
		Distichlis spicata	C
		Phragmites australis	C
	Rushes	Juncus effusus	A
		Juncus balticus	A
		Eleocharis palustris	C
	Herbs	Cotula coronopifolia	C
		Atriplex patula	C
		Potentilla pacifica	C
		Plantago maritima	C
Grass-Herb	Grasses	Holcus lanatus	A

(Continued)

Table A10 (Continued)

Habitat Type	Life Form	Species	Relative Density
		Agrostis alba	C
		Festuca rubra	C
	Herbs	Rumex acetosella	A
		Chenopodium album	C
		Solidago canadensis	C
		Epilobium angustifolium	C
		Tanacetum douglasii	C
		Rumex acetosa	U
		Epilobium angustifolium	?
Lowland Shrub	Rushes	Equisetum arvense	A
	Grasses	Holcus lanatus	A
	Shrubs	Cytisus scoparius	A
		Alnus rubra	A
Dike	Grasses	Holcus lanatus	A
		Agrostis alba	A
	Herbs	Achillea millefolium	C
		Epilobium angustifolium	U
	Shrubs	Rubus discolor	A
		Sambucus racemosa	C
		Cirsium arvense	C
	Trees	Aster subspicatus	C
		Salix sp.	U
		Arbutus menziesii	U
		Betula sp.	U
		Salix scouleriana	U

(Continued)

Table A10 (Concluded)

Habitat Type	Life Form	Species	Relative Density
Upland Seral Shrub	Grass	Holcus lanatus	C
	Herb	Melilotus alba	A
		Epilobium angustifolium	C
		Trifolium repens	C
		Rumex acetosella	C
	Trees	Alnus rubra	C

Table A11

Vegetation Composition and Relative Density of Jetty Island

Habitat Type	Life Form	Species	Relative Density
Dune	Grasses	Elymus mollis	A
Storm Tide Plain	Sedges	Carex macrocephala	U
Low Marsh	Grasses	Poa sp.	C
		Salicornia virginica	A
		Ruppia maritima	U
	Sedges	Carex lyngbyei	C
	Herbs	Atriplex patula	C
Grass-Herb	Grasses	Festuca myuros	C
		Aira caryophyllea	C
		Elymus mollis	U
	Herbs	Lepidium virginicum	C
		Rumex acetosella	C
		Hypericum perforatum	U
Shrub	Sedges	Carex macrocephala	A
	Herbs	Rumex acetosella	C
	Shrubs	Cytisus scoparius	A

Table A12

Vegetation Composition and Relative Density of Padilla Bay Islands

Habitat Type	Life Form	Species	Relative Density
Low Marsh	Sedges	Carex lyngbyei	C
	Herbs	Triglochin maritimam	C
		Salicornia virginica	C
		Atriplex patula	U
Dune	Grasses	Elymus mollis	A
		Bromus tectorum	C
		Festuca myuros	C
		Agrostis exarata	C
	Herbs	Cirsium vulgare	U
Grass-Herb	Grasses	Bromus tectorum	C
		Festuca myuros	C
		Elymus mollis	U
		Agrostis exarata	U
	Herbs	Cirsium vulgare	C
		Lotus corniculatus	C
		Chenopodium album	U

APPENDIX B: INDEX TO PLANT SPECIES OF PACIFIC NORTHWEST ESTUARINE ISLANDS[1]

Family Genus, Specific Epithet, Authority	Common Name
Nonvascular Plants (Algae[2], Mosses[3], Horsetail[4], and Ferns[4])	
Brachytheciaceae	
Eurhynchium oreganum (Sull.) Jaeg. and Sauerb.	feather moss
Bryaceae	
Hylocomium splendens (Hedw.) B.S.G.	stair step moss
Equisetaceae	
Equisetum arvense L.	common horsetail
Polypodiaceae	
Athyrium filix-femina (L.) Roth	lady-fern
Polypodium glycyrrhiza D.C. Eat.	licorice-fern
Polystichum munitum (Kaulf.) Presl var. *imbricans* (DC. Eat.) Maxon	sword-fern
Polytrichaceae	
Polytrichum juniperinum (Hedw.)	juniper haircap moss
Rhytidiaceae	
Rhytidiadelphus loreus (Hedw.) Warnst.	little shaggy moss
Ulvaceae	
Ulva lactuca L.	sea lettuce
Vascular Plants (Grasses[4], Herbs[4], and Shrubs and Trees[4])	
Araceae	
Lysichitum americanum Hult. and St. John	skunk-cabbage

1) Literature cited may be found at the end of the main text pages.
2) Nomenclature after Palmer and Fowler 1975.
3) Nomenclature after Lawton 1971.
4) Nomenclature after Hitchcock et al. 1955-1969 and Hitchcock and Cronquist 1973.

Family Genus, Specific Epithet, Authority	Common Name
Balsaminaceae	
Impatiens noli-tangere L.	touch-me-not
Betulaceae	
Alnus rubra Borg.	red alder
Betula sp.	birch
Caprifoliaceae	
Lonicera involucrata (Rich.) Banks	bearberry honeysuckle (black twin-berry)
Sambucus racemosa L. sp. *arborescens* (T. and G.) Gray	coast red elder
Symphoricarpos albus (L.) Blake	common snowberry
Viburnum edule (Michx.) Raf.	high-bush cranberry
Caryophyllaceae	
Cardionema ramosissima (Weinm.) Nels. and Macrb.	sandmat
Honkenya peploides (L.) Ehrb.	sea purslane
Spergularia canadensis (Pers.) G. Don	Canadian sandspurry
Spergularia macrotheca (Hornem.) Heynh.	beach sandspurry
Chenopodiaceae	
Atriplex patula L. sp. *littoralis* (L.) Gray	shore orache
Chenopodium album L.	lambsquarter
Salicornia virginica L.	pickleweed (glasswort)
Compositae	
Achillea millefolium L.	yarrow
Agoseris heterophylla (Nutt.) Greene	false-dandelion
Ambrosia chamissonis (Less.) Greene	silver bursage
Anaphalis margaritacea (L.) B. and H.	pearly-everlasting
Anthemis cotula L.	mayweed
Aster subspicatus Nees	Douglas' aster

Family Genus, Specific Epithet, Authority	Common Name
Cirsium arvense (L.) Scop.	Canadian thistle
Cirsium vulgare (Savi) Tenore	common thistle
Cotula coronopifolia L.	brass button
Gnaphalium purpureum L.	purple cudweed
Hieracium sp.	hawkweed
Hypochaeris radicata L.	spotted cats-ear
Senecio sp.	ragwort
Senecio vulgaris L.	old-man-in-the-spring
Solidago canadensis L.	meadow goldenrod
Sonchus arvensis L.	field milk-thistle
Sonchus oleraceus L.	common sow-thistle
Tanacetum douglasii DC.	northern dune tansy
Tanacetum vulgare L.	common tansy
Taraxacum officinale Weber	common dandelion
Convolvulaceae	
Convolvulus sepium L.	lady's-nightcap
Convolvulus soldanella L.	beach morning-glory
Cornaceae	
Cornus nuttallii Aud.	Pacific dogwood
Cruciferae	
Cakile edentula (Bigel.) Hook.	American searocket
Cakile maritima Scop.	European searocket
Lepidium virginicum L. var. *menziesii* (D.C.) Hitchc.	tall peppergrass
Cupressaceae	
Chamaecyparis lawsoniana Parl.	Port Orford cedar
Cyperaceae	
Carex lyngbyei Hornem.	Lyngby's sedge
Carex macrocephala Willd.	large-headed sedge
Eleocharis palustris (L.) R. and S.	common spike-rush
Scirpus americanus Pers.	three-square bulrush

Family Genus, Specific Epithet, Authority	Common Name
Ericaceae	
Arbutus menziesii Pursh	Pacific madrone
Gaultheria shallon Pursh	salal
Gramineae	
Agropyron intermedium (Host) Beauv.	wheatgrass
Agropyron repens (L.) Beauv.	quack grass
Agrostis alba L.	creeping bentgrass
Agrostis exarata Trin.	spike bentgrass
Aira caryophyllea L.	silver hairgrass
Ammophila arenaria L.	European beachgrass
Bromus mollis L.	soft chess
Bromus secalinus L.	ryebrome
Bromus tectorum L.	cheat grass
Calamagrostis canadensis (Michx.) Beauv.	bluejoint reedgrass
Dactylis glomerata L.	orchard-grass
Deschampsia caespitosa(L.) Beauv.	tufted hairgrass
Distichlis spicata (L.) Greene	saltgrass
Elymus mollis Trin.	American dunegrass
Festuca myuros L.	rat-tail fescue
Festuca rubra L.	red fescue
Holcus lanatus L.	common velvetgrass
Hordeum brachyantherum Nevski	meadow barley
Phalaris arundinacea L.	reed canarygrass
Phragmites australis(L.) Trin.	common reed
Poa sp.	bluegrass
Polypogon monspeliensis (L.) Desf.	rabbitfoot polypogon
Grossulariaceae	
Ribes lacustre (Pers.) Poir.	swamp gooseberry
Hypericaceae	
Hypericum perforatum L.	Klamath weed

Family Genus, Specific Epithet, Authority	Common Name
Iridaceae	
Iris pseudacorus L.	yellow flag
Juncaceae	
Juncus balticus Willd.	Baltic rush
Juncus effusus L.	soft rush
Juncaginaceae	
Triglochin maritima L.	seaside arrowgrass
Leguminosae	
Cytisus scoparius (L.) Link	Scotch broom
Lathyrus japonicus Willd.	beach pea
Lotus corniculatus L.	birdsfoot-trefoil
Lupinus littoralis Dougl.	seashore lupine
Lupinus sp.	lupine
Melilotus alba Desr.	white sweet-clover
Trifolium pratense L.	red clover
Trifolium repens L.	white clover
Trifolium wormskjoldii Lehm.	springbank clover
Ulex europaeus L.	furze (gorse)
Vicia gigantea Hook.	giant vetch
Nyctaginaceae	
Abronia latifolia Esch.	yellow abronia
Oleaceae	
Fraxinus latifolia Benth.	Oregon ash
Onagraceae	
Epilobium angustifolium L.	fireweed
Epilobium watsonii Barbey	Watson's willow-herb
Oenothera hookeri T. and G.	Hooker's evening-primrose
Orchidaceae	
Habenaria dilatata (Pursh) Hook.	white bog-orchid
Pinaceae	
Picea sitchensis (Bong.) Carr.	Sitka spruce

Family Genus, Specific Epithet, Authority	Common Name
Pinus contorta Loud.	lodgepole pine (coast pine)
Pseudotsuga menziesii (Mirb.) Franco	Douglas fir
Plantaginaceae	
Plantago lanceolata L.	English plantain
Plantago maritima L. sp. *juncoides* (Lam.) Hult.	sea plantain
Polygonaceae	
Polygonum paronychia Cham. and Schlecht.	black-knotweed
Rumex acetosa L.	kitchen sorrel
Rumex acetosella L.	sheep sorrel
Rumex crispus L.	curly dock
Rumex persicarioides L.	yellow dock
Rumex salicifolius Weinm.	willow dock
Rhamnaceae	
Rhamnus purshiana DC.	cascara
Rosaceae	
Fragaria virginiana Duchesne	broadpetal strawberry
Physocarpus capitatus (Pursh) Kuntze	Pacific nine-bark
Potentilla pacifica Howell	Pacific silverweed (marsh cinquefoil)
Rosa gymnocarpa Nutt.	baldhip rose
Rubus discolor Weihe and Nees	Himalayan blackberry
Rubus laciniatus Willd.	evergreen blackberry
Rubus leucodermis Dougl.	black raspberry
Rubus spectabilis Pursh	salmonberry
Sorbus aucuparia L.	European mountain-ash
Sorbus sitchensis Roemer	Sitka mountain-ash
Rubiaceae	
Galium aparine L.	cleavers
Galium sp. L.	bedstraw

Family Genus, Specific Epithet, Authority	Common Name
Galium trifidum L.	small bedstraw
Ruppiaceae	
Ruppia maritima L.	ditch-grass
Salicaceae	
Populus trichocarpa T. and G.	black cottonwood
Salix sp.	willow
Salix hookeriana Barratt	Hooker willow
Salix scouleriana Barratt	Scouler willow
Scrophulariacea	
Orthocarpus castillejoides Benth.	paintbrush owl-clover
Scrophularia californica Cham. and Schlecht.	California figwort
Typhaceae	
Typha latifolia L.	cattail
Umbelliferae	
Angelica lucida L.	sea-watch
Conioselinum pacificum (Wats.) Coult. and Rose.	hemlock-parsley
Heracleum lanatum Michx.	cow-parsnip
Oenanthe sarmentosa Presl.	Pacific water-parsley
Urticaceae	
Urtica dioica L.	stinging nettle
Zosteraceae	
Zostera marina L.	eelgrass

APPENDIX C: INDEX TO BIRD SPECIES[1]

Family Genus, Specific Epithet	Common Name
Accipitridae	
Buteo jamaicensis	red-tailed hawk
Anatinae	
Anas platyrhynchos	mallard
Ardeidae	
Ardea herodias	great blue heron
Charadriidae	
Charadrius vociferus	killdeer
Laridae	
Sterna caspia	Caspian tern
Larus californicus	California gull
Larus delawarensis	ring-billed gull
Larus glaucescens	glaucous-winged gull
Larus occidentalis	western gull
Larus philadelphia	Bonaparte's gull
Sterna hirundo	common tern
Phalacrocoracidae	
Phalacrocorax auritus	double-crested cormorant
Phasianidae	
Lophortyx californicus	California quail

1) Nomenclature after AOU 1957 and AOU 1973. (Literature cited may be found at the end of the main text.)

APPENDIX D: INDEX TO MAMMAL SPECIES[1]

Order: Suborder Genus, Specific Epithet, Authority	Common Name
Carnivora: Pinnipedia	
Phoca vitulina (Linnaeus)	harbor seal
Rodentia: Myomorpha	
Rattus norvegicus (Berkenhout)	Norway rat
Rodentia: Hystricomorpha	
Myocastor coypu (Molina)	nutria
Insectivora: (none)	
Sorex sp.	shrew

1) Nomenclature after Ingles 1965. (Literature cited may be found at the end of the main text.)

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Peters, Carl F
Colonial nesting sea and wading bird use of estuarine islands in the Pacific Northwest / by Carl F. Peters ... [et al.], John Graham Company, Seattle, Washington. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
xi, 179, [30] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-78-17)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-77-C-0046 (DMRP Work Unit No. 4F01E)
References cited: p. 177-179.

1. Birds. 2. Dredged material. 3. Estuarine ecology. 4. Habitats. 5. Islands (Landforms) 6. Pacific Northwest. 7. Plant community. 8. Seabirds. 9. Shore birds. I. John Graham and Company. II. United States. Army. Corps of Engineers. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-78-17.
TA7.W34 no.D-78-17